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C/o State Rivers and Water
Supply Commission,
100 Exhibition St., Melbourne, C.1.

Assistant Editor:

P. F. BUTLER, M.Agr.Sc.,
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Business Manager:

J. A. ROBERTS, B.Agr.Sc.,
Executive Officer,
Australian Institute of Agricultural
Science,
226 Clarendon St.,
East Melbourne, C.2.
Telephone: JA 4735.

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ARTICLES

SOME ASPECTS OF ORGANIC CHEMICAL RESEARCH AS APPLIED TO AGRICULTURE

By J. R. PRICE

Agriculture, more than any other field of human activity, today requires the combined efforts of scientists of all shades of training if it is to meet the demands made upon it. So, although the following discussion is concerned only with some of the ways in which organic chemistry can contribute to agricultural research, the need for integration with other sciences has not been overlooked. It is evident that in order to sustain our present standards of living, we are becoming increasingly dependent on what we know as organic chemistry, though its impact is greater on the secondary industries than it has yet been on agriculture. The introduction of organic herbicides, pesticides and so on, is more recent than, for example, the development of synthetic dyestuffs or the plastics industry. Nevertheless, the influence of chemical industry on agriculture is extensive and is continually expanding; it is manifest not only in greater efficiency of production, but also in more effective utilisation of agricultural products.

The purpose of this article, however, is not to discuss *faits accomplis*, it is to consider two or three of the many ways in which organic chemical research can contribute to further advances in agricultural knowledge and practice. Attention will be focused particularly on investigations relevant to this country.

J. R. PRICE, D.Sc., D.Phil., is Senior Principal Research Officer with the C.S.I.R.O. Division of Industrial Chemistry at Fishermen's Bend, Melbourne.

Medicinal and Other Crops

Among the many problems facing agriculture is the threat in some countries of the world, of temporary over-production of foodstuffs which, despite an overall world shortage, cannot for economic or political reasons be disposed of where they are needed. Such a situation can be met, with the minimum of embarrassment to the farmer, by the introduction of new crops—a matter which is at present receiving considerable attention. Current surveys by the United States Department of Agriculture, for example, have as their main objective the increased stability of the agricultural industry which would result from a more diverse cropping potential.

The gradual evolution of Western civilization in Europe and the Middle East had as an integral feature the development, by selection, of more and more improved strains of domestic animals and plants. This process depended, where plants were concerned, on a thorough, though undesigned, empirical survey of the potentialities of the European and middle-eastern floras, and because of this thorough sifting we should not expect to find many European species among the new crop plants introduced into the western economy in the past two or three hundred years.* This, of course, is essentially true, maize, tobacco, potatoes, cinchona and so on, all originating in the

*An exception, or more correctly, a reintroduction, is buckwheat (**Fagopyrum esculentum**) now cultivated for its content of the flavonol glycoside rutin, though it has had to compete in the rutin market with certain **Eucayptus** species.

new world. So it is that the relatively unexplored floras of the Americas, the Far East, the Indies, Africa and Australia constitute a reserve of plant species in which many new crop plants undoubtedly remain to be discovered. The first Europeans to settle in Australia were impressed by the qualities of the new plant communities with which they were faced, particularly by the characteristic odour of essential oils met with in the Australian bush. They very soon —in the first year of the settlement—distilled some *Eucalyptus* oil, and used it as a substitute for oil of peppermint in the treatment of wind and colic. Out of this sprang an oil industry in which Australia, the original home of the Eucalypt, now has to face vigorous competition with plantation oils from, for example, Portugal, France, Italy, India and Brazil, the latter country having a current planting programme of several million eucalypt trees per annum. Likewise, the tanning qualities of the bark of Australian wattles, such as *Acacia mollissima*, have led to their establishment as crop plants in South Africa. On the opposite side of the ledger, of course, is the fact that most of Australia's crop plants are not indigenous and the numbers of these are continually increasing. For example, we are now growing linseed in partial fulfilment of our drying oil requirements and at the same time are actively investigating the seed oils of other species, indigenous and exotic, as possible crops.

A need during the second World War to meet a possible shortage of vital imported drugs from native sources led to the commercial exploitation of two Australian *Duboisia* species, *D. myoporoides* and *D. leichhardtii*, from which good yields of the tropane alkaloids hyoscine and atropine are obtainable. After the war, under the aegis of the C.S.I.R., a general survey of the chemical and pharmacological potentialities of the Australian flora was instituted and one outcome has been the recent discovery of the hypotensive alkaloid reserpine, in *Alstonia constricta*. *Duboisia* species are being cultivated at present but only on a small scale, the bulk of the harvested leaf being from natural stands, so that it cannot yet be regarded as of much significance as a crop plant. Should the demand for *Duboisia* be maintained—and indications are that the current harvest from natural stands will not nearly meet commercial requirements — and a demand for *Alstonia* developed, there is little doubt that both will be met increasingly from cultivated sources. The value of the alkaloid reserpine in the treatment of hypertension and mental disorders, following the utilisation of plant constituents as intermediates in the synthesis of cortisone has stimulated the interest of the pharmaceutical industry in plants as sources of potential drugs and exploration of the Australian and New Guinea floras, which has already revealed their chemical versatility, is being actively prosecuted by the C.S.I.R.O. in collaboration with industrial firms. From this collaboration we can look forward to further discoveries which may influence agriculture as well as medicine. One can never be sure of the outcome of such a survey and it is worth recording that out of an investigation of the plants used by Nevada Indian "medicine men" came the discovery that a very common and otherwise useless plant—the "creosote bush" —was an excellent source of an industrial antioxidant, nordehydroguaiaretic acid, now being produced by two factories in large amounts.

Stock Poison Plants

In every country agriculture suffers to a greater or lesser degree from losses caused by plants toxic to livestock. The extent of these losses, even from the more obvious and highly toxic species, can only be guessed at, but they are undoubtedly considerable in Australia. For example, Gidgee (*Acacia georginae*) is believed to have cost pastoralists upwards of £100,000 per annum in Queensland in recent years. And it is important to realise

that such highly toxic plants represent only a fraction of what can legitimately be described as stock poison problems; in this article the term "poison plant" is not used in a restricted sense to describe only plants which possess a high degree of toxicity. It will be used to cover all plants the ingestion of which results in metabolic abnormalities sufficient to lead to economic loss. In this sense, for example, the Dwalganup strain of subterranean clover was in certain environments a "poison plant". In practice, it may well be that important pasture plants such as subterranean clover or *Phalaris tuberosa* constitute the more serious "poison plant" problems.

Poison plants which, other things being equal, are undesirable pasture ingredients, are obviously best eradicated wherever practicable. But in many instances—possibly in most—eradication is not practicable and the best that can be aimed at is the evolution of methods of pasture management which keep losses down to a minimum. In very few instances have serious efforts been made to counter losses due to poison plants by other than such empirical methods. But this kind of problem is continually arising, perhaps even more rapidly nowadays in the wake of improved pastures, heavier stocking, utilisation of problem soils and so on, and to some of them a systematic approach must be made. It is essential for such an approach that the toxic principle be isolated to facilitate accurate testing, and its structure determined. Even the selection of strains with a low content of the undesirable constituent can only be achieved efficiently when the nature of the offending component is established. At the same time it must be realised that chemical studies of stock poison plants will prove sterile unless they form part of a broader pattern of investigation, they should precede or proceed side by side with, adequate biological programmes. Much chemical work on stock poison plants in other parts of the world has been incomplete in the biochemical sense and unproductive economically because it has not been properly followed up.

As mentioned above, poison problems of varying degrees of economic severity are continually arising—for example, *Halogeton* in post-war U.S.A., gidgee in Queensland and the Northern Territory, heliotrope poisoning in the Southern States of Australia, "walkabout" or *Crotalaria* poisoning in the north, and so on. The cause and manner of the losses vary considerably and the likelihood of successfully combating them empirically is not very great. In each case one of the first questions the investigators ask is "what is the toxic principle?" The answer to this necessitates, of course, a detailed chemical examination of the active substances, the isolation of which may involve tedious fractionations based on biological activity tests.

A number of such investigations are in progress in Australia at the present time, most emphasis being given to plants which contain liver-damaging alkaloids of the pyrrolizidine group. Recognition of the effect of these alkaloids has been gradually building up since Gilruth described the occurrence of liver cirrhosis in horses and cattle after eating ragwort, *Senecio jacobea*. They are widely distributed, occurring not only in *Senecio* and related composites but also in the leguminous genus *Crotalaria* and in many members of the family Boraginaceae. A great many species containing them occur throughout Australia; how many of these are toxic is not known, nor is the extent to which less obvious species may contribute to an effect ascribed to the more obvious trouble makers, but information is slowly accumulating. For example, chemical studies of the hepatotoxic alkaloids of *Heliotropium europaeum* have recently been concluded and preliminary accounts of the extensive biological data available on heliotrope poisoning have appeared in reports of the Toxaemic Jaundice Investigation Committee. A number of *Crotalaria* species

are under examination, some because they are directly implicated in stock diseases such as Kimberley Horse Disease and others because, if they are shown *not* to be toxic, they would be extremely valuable as pasture legumes for distribution in Northern Australia. The search for these much-needed legumes is far from being a simple one since the Leguminosae probably contain more poisonous species with more varied toxic principles than any other family. Consequently the agronomist must always be on the lookout for such potential dangers and, while it is not suggested that chemical examination can replace biological testing of species undergoing introduction trials, it may, in certain cases, save expensive and time-consuming feeding experiments. For example, identification of the hepatotoxic alkaloid monochotaline—a relatively simple matter—in a *Crotalaria* species would render that species highly suspect.

A feature of the occurrence of the pyrrolizidine alkaloids is the extent to which they may be present in the plant in the amine-oxide form and it has been suggested that this results in greater palatability and consequently readier consumption by livestock. Whether or not this conjecture is well-founded, it is evident that the amine oxides are capable of producing the characteristic liver damage. The occurrence of amine oxides, however, is not limited to those of the pyrrolizidine bases. Examination of the Western Australian blue lupin which, despite its great value in certain areas of Western Australia, has given rise to a number of cases of acute poisoning in recent years, has revealed that here also amine oxides contribute largely to the alkaloid pattern. The biological significance of this situation has not yet been assessed but it does mean that earlier assays based on total tertiary base content could be grossly misleading. It probably means, also, that much of the tremendous volume of analytical work done overseas in connection with selection of "sweet" strains of lupins has no quantitative significance.

A number of stock poison plants other than those containing alkaloids are under investigation in Australia at present, including some well-known pasture species such as *Phalaris tuberosa* which in certain environments gives rise to "Phalaris staggers". Orthodox poison plants being studied include "gidgee", *Gastrolobium* species, *Indigofera enneaphylla* — the cause of Birdsville disease of horses—and white wood, *Atalaya hemiglauca*. Much remains to be done, and we can unfortunately be sure that for a long time to come new problems of this type will arise as we modify and develop our agricultural practices.

Root Secretions

In the preceding pages I have outlined two fields in which the chemist is concerned with the study of metabolites which are accumulated to a greater or lesser extent in various parts of the plant—leaves, bark, roots, seeds, etc. Recently, however, more and more attention is being directed to substances which, likewise, are produced by the plant but then migrate from it through the root system into the surrounding soil. The study of such substances is very much in its infancy, but since, as we shall see, it has tremendous implications for agriculture and since some work is being undertaken in this country a brief account is worthwhile. Everyone is familiar with the capacity of plants for taking up essential nutrients from the soil through their root systems, but the reverse process, the giving-out of substances to the soil is much less familiar, at least to the layman. In fact, almost nothing is known of the chemistry of the substances concerned or of the amounts in which they are excreted, and even less about the manner in which the nature and amount of these substances may vary throughout the life cycle of the plant or with changing environment. Something is known, however, about the biological properties

of certain of these exudates and it is this biological evidence that makes clear the need for chemical and physiological investigations. First let me give one or two examples to establish the fact that plants do excrete substances from their roots. Seedsmen have known for a long time that one can distinguish between the seeds of certain *Lolium* species by germinating on wet filter paper and examining under ultraviolet light. The filter paper in the immediate vicinity of roots of germinating *L. multiflorum* fluoresces bright blue while no fluorescent material is produced by *L. perenne*. It has been shown at Rothamstead that roots of growing clover give out substances, themselves colourless, which can be adsorbed on to bentonite which then becomes highly coloured. Perhaps more spectacular is a recent American observation that α-methoxyphenylacetic acid—which causes a characteristic malformation of leaves—when applied to the stem of one plant is absorbed, passes down into the root system, out through the roots into the soil and can then be taken up by the roots of a different individual causing it to undergo the characteristic leaf malformation.

Biologically — and economically — root exudates can be classified arbitrarily in four groups, as participating in plant-plant interactions, in plant microorganism interactions, plant-invertebrate interactions and plant-soil interactions.

A great deal of historical material of an empirical nature is available concerning plant-plant interactions other than straight-out competition for nutrients. It has been believed for thousands of years that grapes grow well in association with elms and that certain grains produce better when grown together than separately. Likewise *Cyperus* and some water-lilies are reputedly beneficial to the growth of rice. On the other hand there are many reported detrimental effects of one species on another—the germination of *Agrostemma* is inhibited by secretions of *Beta*, so that one rarely finds *Agrostemma* growing in a beet field; a forage plant, *Leersia hexandria*, and certain sedges are said to reduce the yield of a following rice crop, while wheat is reported not to produce as well after sorghum as after maize. As far as the effect on a following crop is concerned, of course, the cause may not necessarily be root secretions, but decomposition products of root wastes.

However, these empirical observations do not constitute the only evidence. It appears to be well established that the black walnut (*Juglans niger*) is able to kill other plants such as pines growing within range of its roots. In the course of wartime work on the cultivation of guayule for rubber production it was observed that stunting occurring in nurseries was due to the excretion by the roots of a substance which inhibited the growth of guayule itself. The substance was isolated and shown to be cinnamic acid. It is of little economic importance, however, as the cinnamic acid is rapidly destroyed by soil microorganisms and stunting is only observed in pot culture or when plants are grown close together as in nursery rows. But the discovery is of interest ecologically and accounts for the field observation that guayule seedlings are *not* found in the wild growing under guayule bushes but under other species. The economic aspect of these plant-plant interactions, however, is largely concerned with root parasites. A number of plants are known which are parasitic on the roots of other species, the host-parasite relation often being very specific. In particular, species of *Striga* and *Orobanche* are parasitic on a number of important economic crops in tropical and Mediterranean countries—*Striga*, for example, can be a nuisance to cane-growers in Queensland. It has been rigorously established that the seeds of *Striga* and *Orobanche* normally germinate only in the vicinity of a host root and that this germination is stimulated by a substance or substances given out from the roots of the potential host. The

structures of these germination factors are not yet known, but obviously a knowledge of them would open the way to synthesis and a possible economic means of control.

Plant-microorganism relations represent by far the most important of the root secretion interactions. The population of soil microorganisms is in a delicate state of balance which may be upset in a variety of ways, and this balance is profoundly influenced by the roots of plants growing in the soil. Root secretions stimulate the development of microorganisms by supplying food requirements or growth factors, the population density in the "rhizosphere"—the immediate vicinity of the root system—being fifty to a hundred, or even a thousand times as great as in the soil outside the root zone. But the rhizosphere is not only a zone in which microorganisms concentrate and multiply. Because of differences in the composition of root secretions and because of specific chemical requirements of different species of microorganisms, a process of selection operates and, in general, each species of plant gives rise to a more or less defined microbial population within its rhizosphere. When pathogenic organisms are present in the soil the effect of root exudates may be beneficial or may be deleterious to the plant—they may determine whether the plant is resistant or susceptible to attack by the microorganism concerned, a susceptible variety producing root secretions which stimulate the growth of the microorganism while the resistant variety does not. Again, a number of soil microorganisms are antagonistic to pathogenic fungi and several fungistatic metabolites have been isolated and studied chemically. Clearly then, the incidence of disease in plants can in some cases be correlated with the nature and properties of the root secretions.

But even more important is the bearing of root secretions on symbiotic nitrogen fixation by legumes. This story is a complex one, but one of the established points is that nodule formation on legume roots is stimulated by exudates from the roots themselves. Yet another significant phenomenon is that of mycorrhizal association, many common tree species growing in close association with fungi present in the soil. Such "mycorrhiza" are often very specific and there is evidence that the plant roots put out substances which stimulate the growth of the symbiotic fungus.

Similar specific associations primarily dependent on root secretions are also involved in plant-invertebrate relationships, the most thoroughly investigated being concerned with the potato eelworm. This nematode is responsible for a great deal of damage to potato crops in Europe and in at least one area in the U.S.A. The losses caused in England alone are estimated at £2,000,000 per annum. The related beet eelworm is such a scourge in the eastern counties of England that the cropping of infected land is subject to statutory controls to limit the intensity of infestation. It has been rigorously established that the hatching of potato eelworm cysts is brought about by a substance or substances excreted by the host roots and the problem cannot be dealt with satisfactorily by a normal crop rotation since the cysts remain viable in the soil for fifteen to seventeen years. As in the case of root parasites such as *Striga* it is clear that a knowledge of the structure of the "hatching factor" would open the way to achieving control of the pest. In this context it is worth recording that some reduction of the ravages of the potato eelworm can be achieved by growing mustard with the potato crop—the mustard roots excreting substances which either inhibit hatching of the cysts or have a directly toxic effect on them. The potato eelworm is just one of the large group of nematodes which more and more are being recognised as serious enemies of agriculture. In the opinion of some they may be responsible for many of the reported cases of "soil sickness", a term applied to a condition of the soil developed

after growing certain crops for many years in the same soil and involving a gradual decline in productivity and inability to grow the same crop again. On the other hand there are some instances where the available evidence seems to exclude the idea that nematodes or other micro-organisms are responsible and points to a building-up of toxins in the soil. Such toxins could be metabolites of microorganisms associated with the plant in question or perhaps they may be produced directly by the plant itself, but in either case the root secretion contributes directly to the occurrence of the toxins, as it does to other aspects of plant/soil interactions.

Some investigators consider that substances excreted into the soil by higher plants may act directly on the soil by making nutrients or other materials available to the plant. For example, lupins, grown side by side with oats, or immediately preceding an oat crop, enable the oats to take up phosphorus more effectively, possibly because of lupin root secretions which "solubilize" phosphate. However, other explanations are feasible, one being that lupin root secretions act as stimulants for microorganisms, which produce "phosphate-solubilizing" metabolites, just as mycorrhizal associations enable pines to take up phosphorus more effectively. But whether interaction between plant and soil by way of root exudations is direct or whether it involves the mediation of microorganisms there is no doubt of its significance nor of the value to us of a knowledge of the nature of the operative intermediates. The situation is a challenge to the organic chemist and one which he alone is equipped to meet.

Conclusion

Studies of plants as sources of biologically active substances and of plant secretions are then two fields in which organic chemical research can provide the basis for further advances in agriculture. But these are only two of such fields and it is well to realise that excluding the obvious such as herbicides, insecticides, soil conditioners, etc., there are many problems awaiting detailed chemical attention. Stimulants and inhibitors of growth and germination and substances responsible for disease resistance present fascinating and important structural problems the solution of which will certainly be of service to agriculture in advancing our knowledge of the selective control of plant growth. But it is the relation between the plant and its immediate environment—the soil—which raises the most far-reaching issues. We have seen how root secretions play a vital part in determining the nature of the microorganisms in the rhizosphere and thus of the metabolites of the microflora. These, in turn, as well as influencing the growth of the plant itself and contributing to the total soil organic matter, can affect the inorganic constituents of the soil in various ways. And it is not only by means of root secretions that the plant can influence the medium in which it grows. Particularly under forest conditions a considerable amount of organic matter in the form of leaves, bark, etc., falls on the soil surface and slowly decays, the acidity generally increasing in the more decomposed layers altering the soil structure through solution and consequent migration of iron and aluminium oxides. It has recently been shown, however, that such changes in soil character are by no means due solely to the effect of acid decomposition products of accumulated organic debris. Aqueous extracts of fresh, unhumified, leaves contain relatively simple organic compounds capable of dissolving ferric and aluminium oxides from the soil. There is little doubt that these complexing substances present in leaf leachates play an important part in the determination of soil structure.

Clearly the basis for advance in agriculture must be a full appreciation of the

essential unity of the soil-plant-animal system, and for this reason alone the solution of individual problems in terms of single disciplines such as physiology or physics or chemistry, is not enough. It cannot be over-emphasised that in a search for new crop plants or the investigation of stock poisons just as in the study of plant/soil relations or the thousand and one other problems in which organic chemistry can contribute to agricultural research, collaboration must be the keynote. The chemist is just as aware as his biological colleagues of the necessity for such collaboration, with pharmacologist or pathologist, with geneticist or physiologist, with agronomist or microbiologist, if anything but academic ends are to be achieved.

(*Received for publication September* 15, 1955.)

BOOK REVIEWS

A STATISTICAL STUDY OF LIVESTOCK PRODUCTION AND MARKETING

By CLIFFORD HILDRETH and F. G. JARRETT

[*Cowles Commission for Research in Economics. Monograph No.* 15. *John Wiley & Sons, Inc.* 1955. $4.50.)

Economics, at an elementary level, with its conception of supply and demand curves, is familiar to all, but it is not so well known that there is an allied field—*econometrics*—which is concerned, amongst other things, with such curves as they refer to actual commodities and populations and with their determination in quantitative terms. This monograph is a contribution to econometrics, with the emphasis on methodology. Livestock production and marketing was selected for study mainly because suitable data was readily available and in a convenient form. Nevertheless, it is of interest to agriculturalists even though not primarily directed to them.

Briefly, the authors have taken this field—the production and marketing of livestock in the United States, 1920-49—and have set up an economic model as fully descriptive of the structure of the field as they have been able, reasonably, to make it. They have estimated the parameters of the model by several alternative methods which have thus been compared and they have predicted the 1950 values of certain variates which by comparison with the actual values provide further evidence as to the adequacy of their procedures. The measures of production, sales, etc., are aggregates of the different types of livestock expressed in terms of dollars at average prices and the economic model finally adopted is a considerable refinement of a simpler initial one which derives from the viewpoint that production in any one year is determined by the beginning inventory and the total feed consumed in that year.

In such a model as this, certain variables (livestock production, sales, etc.) are regarded as being determined by others (quantities of protein feed consumed, national income, etc.), and the ultimate purpose involved is the prediction of the former variables for the latter.

The authors have succeeded in writing a book which is more than usually satisfying as regards the lucidity and logic with which they have presented the various phases of the investigation and one which provides an excellent example of what can be achieved, given adequate data, by the somewhat abstruse methods of econometrics. The statistical nature of certain chapters may deter many agriculturalists from perusing this book at all closely, but it should not be allowed to do so for there is much discussion that cannot fail to be of value to anyone who is concerned to think seriously about the kind of problems dealt with in this monograph.

R. JARDINE.

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PROCEEDINGS OF SYMPOSIUM ON "THE FLOOD PROBLEM IN NEW SOUTH WALES"

PAPERS READ AT A SYMPOSIUM HELD BY THE NEW SOUTH WALES BRANCH OF THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE ON APRIL 29, 1955.

An understanding of the flood problem in New South Wales is very important because most of the best agricultural land of that State, and many towns, are subject to flooding. Early last year the New South Wales Branch of the Institute arranged for a geographer, an engineer, a soil conservationist, a town and country planner, and an economist to contribute to a symposium on this vital subject; their views are outlined in the next five papers.

Figure 1.

One result of river-bank erosion—damage to buildings. Roads and bridges are also frequently threatened and sometimes destroyed.

Figure 2.

A bridge in the Hunter Valley destroyed in the 1955 flood.

GEOGRAPHICAL DESCRIPTION OF THE FLOOD PROBLEM IN NEW SOUTH WALES

By P. J. DEVERY

The occurrence of the water which causes the floods and the physiography of the valleys in which flooding occurs are the two fundamental geographical factors affecting the flood problem in New South Wales.

Flood Rains

It is from the passage of cyclones that we get most of our rainfall. These storms approach New South Wales from four directions—they can move across south-east Australia from the Great Australian Bight or move up the east coast from the south or move from beyond Darwin across western Queensland and across northern New South Wales, or they can approach the Queensland coast from a north-easterly direction then move south along the coast and off towards the east or south-east. The latter group causes the greatest floods.

These cyclones, developed in the tropics, are heavily laden with water vapour which they deposit along the coast and highlands as they proceed in a general southerly direction. The amount deposited depends on the characteristics of the cyclone and on its speed of travel. Some move quite rapidly but others move slowly and are over the coastal area for several days, in which case heavy and continuous rain results. Many places along the coast have received over 15 inches in 24 hours; Springbrook on the northern border of New South Wales has received 42 inches in two days. Some places on the western slopes have recorded up to 10 inches in 24 hours.

In addition to the above storms, which all generally cover a large area and may lead to widespread flooding, local thunderstorms may produce local or flash floods. Such local floods may be just as disastrous to individuals as the more widespread type.

At the present time there appears to be little prospect of preventing flood rains. Therefore, the geographic approach to the problem must be based on knowledge of the likelihood of occurrence of the storms, an analysis of the types of storms experienced and their rainfall patterns and also a satisfactory system warning of their approach.

At the present time there are large gaps in our knowledge. One of the biggest problems is to calculate the volume of water that has fallen on a catchment and frequently our recording stations are too widely dispersed to obtain accurate details of a storm's behaviour. A much closer network of stations is desirable and this can only be achieved by getting the local citizens to realise how important such readings are to their own ultimate welfare and thus obtaining their assistance in the collection of data. We still have to infer much rainfall data that should have been recorded in the field.

Our flood warning system could be very much improved. A modern development is the establishment of radar stations on the Queensland coast for forecasting the approach of cyclones and the paths they are likely to take when crossing the coast.

P. J. DEVERY, B.Sc., is Lecturer in Physical Geography with the Geography Department of the University of Sydney. *This review was presented at a Symposium on "The Flood Problem in New South Wales", held by the New South Wales Branch of the Institute on April 29, 1955.*

General Physiography

The Dividing Range is the main feature in the State's physiography—it divides the rivers into two sections—those flowing East and those flowing West—and in addition provides the main watershed for both groups.

The height of the Range and its close proximity to the sea ensures that the coastal rivers will be shorter and swifter than their western counterparts, and the numerous spurs projecting from the main range to the coast create a pattern of comparatively small amphitheatre-shaped river valleys. The two largest valleys are those of the Hawkesbury-Nepean and the Clarence, both about 8,500 square miles; the Hunter is slightly smaller at 8,000 square miles and the remainder are considerably smaller. (The Macleay is about 4,400 square miles, Richmond 2,600 square miles and Tweed 420 square miles.)

For descriptive purposes the valleys can be divided into three general sections —the headwater tract, the middle tract and the alluvial flats. The streams show greatest variety in their headwater tracts, for instance, the Macleay drains quite a substantial undulating upland area, representing about ⅓rd of its total drainage area, whereas the other valleys generally have a very much smaller upland area. The Hunter has a relatively low headwater tract due to a drop in the height of the main divide. The middle tracts are more uniform, consisting mostly of narrow valleys with steeply sloping sides and small alluvial flats. The lower alluvial flats of the rivers are very similar, being wide and low-lying and in most cases natural levees have been built up making the river bank higher than the adjacent flats. In many valleys old river courses are marked by swamps and billabongs and these are again used by the river in times of flood.

The long profile of the river indicates the flow characteristics. Most show a relatively steep fall in the headwaters, a gradual flattening out in the middle reaches and then a very flat lower section. (For example, the Hunter rises only 25 ft. in the first 40 miles from its mouth, and the Tweed with a drop of 3,000 ft. to sea level in a total length of 50 miles is only 25 ft. above sea level 25 miles from its mouth.) The result is that after heavy rain there is considerable run-off from the headwaters and, due to the valley shape, this water converges in the middle tract and then spills out over the flats in the lower section. The low flats offer no resistance to the path of the water and soon become inundated.

The physical characteristics which play an important part in the behaviour of the stream are the relationship between rainfall, run-off, river height, and degrees of flooding. From information of this kind it is possible to assess the probable frequency of flooding of any particular area and to plan a suitable flood warning system for each valley.

Information on rainfall patterns and stream behaviour is vital to any plan for successful flood mitigation for it will be difficult to devise satisfactory schemes if we do not know what we are trying to control.

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WATER CONSERVATION AND ITS RELATIONSHIP TO THE FLOOD PROBLEM IN NEW SOUTH WALES

By R. A. YOUNG

To obtain some idea of how much water can fall during flood rains let us examine what happened during the recent Hunter Valley flood in February, 1955. The catchment area above Maitland is 6,710 square miles. We know that the rainfall was in parts over 12 inches and that the average over the whole catchment was 10½ inches. Most of this rain ran off the land because the country had been saturated by previous rains. This is usually the case in floods, the catchment is previously soaked otherwise a large part of the rain would soak in.

Assuming that the run-off was equivalent to 4 inches over the whole catchment (and it would be at least 4 inches) of 6,710 sq. miles then 1½ million acre feet of water flowed into the Hunter River in a few days.*

A Hunter flood is by no means the biggest flood with which to contend although, due to close settlement and cultivation and other improvements, it does more damage than on other rivers in this State.

Very large floods which have been measured or assessed in New South Wales rivers include:—

In 1950 on the Clarence River at Grafton the peak flow reached 500,000 cubic feet per second and the discharge over the flood period was 3 million acre feet.

In 1949 on the Macleay River at Kempsey the peak flow reached 500,000 cusecs and the total discharge 2 million acre feet.

In 1954 the north arm of the Richmond River at Lismore reached 150,000 cusecs as did the south arm at Casino. The combined flood discharge was 820,000 acre feet.

In 1952 there was a disastrous flood in the Lachlan River which reached a peak flow of 190,000 cusecs at Cowra with a total flood discharge of 1.3 million acre feet.

Coming nearer home the Nepean River at Penrith reached 200,000 cusecs in 1949—total discharge 1.3 million acre feet.

In the big flood of 1867 which eclipsed all others for height the peak flow has been assessed, from flood marks, at 550,000 cusecs.

No river channel has been designed by nature to carry a flood flow within its banks. The channel will carry low flows, and perhaps freshets, but flood flows will inevitably overflow on to the flood plain and, during a major flood, the amount carried by the river channel is frequently insignificant compared with the total flow.

If farmers cultivate the flood plains they pay the penalty of periodical inundation with consequent loss of production. A flood is not entirely harmful to them, a deposit of good silt will rejuvenate their land, but the value of the land must not be assessed on the production of good years only, allowance must be

*Subsequent calculations have confirmed these assumptions. The discharge at Maitland was 1,419,000 acre feet, being 36 per cent. of the total precipitation over the catchment area.

R. A. YOUNG, B.C.E., is Commissioner with the Water Conservation and Irrigation Commission of New South Wales. *This paper was presented at a Symposium on "The Flood Problem in New South Wales", held by the New South Wales Branch of the Institute on April 29, 1955.*

made for periodical loss of production due to flooding. If towns and cities be built on a flood plain the inhabitants must be prepared for periodical inundation which, in their case, has no beneficial effects. The problem basically is a human problem that grows out of the ever-expanding trend for population to crowd into the natural flood plains—nature's pathways for flood waters.

The term "flood control" is misleading —it infers "complete control", that is permanent protection under all conditions. Experience demonstrates that permanent and complete control can rarely, if ever, be achieved for either physical or economic reasons.

River basins cannot be compared with each other as the conditions in no two are alike and each represents a separate problem. The shape and condition of the catchment, the size of tributaries and the point at which they join the main stream, the tidal conditions at the mouth and many other factors all influence the varying intensities of floods and compel a separate study of each river.

Nevertheless the basic principles of flood mitigation are common to all rivers, they are:—

1. Delay the run-off from the catchment by soil conservation and afforestation measures.
2. Contain the flood, or a sufficient portion of it, in flood control storages.
3. Improve the river channel by bank protection measures, by dredging and where suitable by river straightening or diverting.
4. Protect valuable areas, where it can be done without detrimental effect, by levee banking and by the provision of flood waterways.

Flood control storages give the greatest measure of relief, the other measures are important but only complementary. If any great measure of reduction of flood flows is desired—then there is no alternative to flood storages.

Let us examine these measures in greater detail:—

1. *Delaying the run-off.* Trees, requiring a lot of moisture, dry out the land so that it will absorb rainfall, also they form a forest litter of leaves, humus, etc., which can absorb and hold twice its own weight of water. The effect of afforestation is not great as flood rains usually follow a period of soaking rain when the ground and litter are saturated. It is significant that floods were just as great, if not greater, when our catchments were in their natural state and at least partially forest covered. Soil conservation methods such as contour drains, silt dams, etc., are good but here again preceding soaking rain has probably filled them and they have a small effect on major floods.

2. *Flood control storages.* While being the most effective measure of flood mitigation storages have the disadvantage of putting out of production, at least temporarily and at unpredictable times, large areas of land. Production is not entirely lost, they might be filled only once in ten years or longer, and in America the storage basins in places are regularly cultivated or used for grazing, the farmers taking the risk of inundation and finding that it pays them to do so.

Water is discharged from the storages as quickly as possible after a flood, in order that the storage will be able to receive and store the next flood—(sometimes major floods occur in quick succession)—and this means that the river is held at near bank level for perhaps several weeks. This keeps the water table high on farm lands with probably injurious results to the crops while it interferes with sewerage and drainage of cities built on the flood plain.

Not all river basins have suitable sites for flood control reservoirs. On the Clarence River, which has the highest

flood discharge, is an excellent site at "The Gorge" forty miles from Grafton. At this site could be built a reservoir to contain almost the whole of a major flood but 100 square miles of country would be periodically inundated. This country, it is claimed, is excellent cattle country with some good alluvial flats, and this fact, together with the cost involved, has prevented the adoption of the Gorge Flood Control Dam Scheme.

Other coastal rivers have not the same possibility. The Macleay river, which floods the Kempsey district, has no suitable dam sites, that is, sites for storages which would hold an appreciable portion of a flood flow. On the Hunter, probably seven dams—three of them being dual purpose—would be required. The cost of flood control dams has, so far, made their adoption prohibitive in Australia while we search, in vain, for cheaper effective methods. On the Ohio River in America, which drains 200,000 square miles, more than 100 flood control storages have been planned and many of them have been built.

3. *Improve the river channel.* A river channel with regular banks and free from shoals will pass more water than one with snags and shoals and eroding banks. It is therefore important that we dredge to remove the shoals, batter the banks and protect them with a vegetative cover of grasses and low trees. But it will then pass only medium flows and freshets and cannot, by itself, cope with flood flows.

4. *Levee banks.* This is the cheapest, most dangerous and most abused method of endeavouring to obtain protection from floods.

Levees built on both sides of a river confine the flood flow and invariably raise flood heights. They temporarily increase the capacity of the waterway and enable it to contain somewhat higher flows. But the large flood must inevitably occur and overtop or burst the levees with greater destruction than if they had not been built. They engender a false sense of security, delaying evacuation of vulnerable areas until, often, it is too late.

By containing medium floods within levee banks the silt is deposited in the river bed, instead of on the adjacent flood plains, and, in consequence, the bed rises until in extreme cases, as on the Mississippi and some European rivers, the bed is higher than the flood plain. The Mississippi is of course an outstanding example of complete leveeing with levees up to 28 feet in height. Before leveeing the maximum flood range was 45 feet at Cairo and 12 feet at New Orleans. Since leveeing it has risen to 60 feet at Cairo and 21 feet at New Orleans. Ring leveeing is advantageous on wide flood plains. That is to say that small valuable areas may be protected by levees provided the flood waterway is not unduly restricted. Nature has provided flood relief storages on many rivers. The best known examples are Hexham Swamp and Louth Park area on the Hunter River. At an early stage of flooding these areas would slowly fill and, being huge in extent, would keep the flood height down. Unfortunately the Louth Park area has been blocked off by levees and dams—contrary to the advice of many old time investigators—with disastrous results. The Hunter builds up to a height of about 37 feet at Maitland in a major flood—much higher than the adjacent Louth Park area. When the levees fail—as they often do—there is a tremendous rush of water into the Louth Park basin. This caused the destruction recently of the Long bridge, the washing away of the railway line and signal box (where 2 men lost their lives) and rapid inundation of many residences, several of which were washed away. The closing off of these natural flood relief storages should be prohibited unless and until artificial flood control storages are constructed on the higher portions of the river system to take their place.

Floodways or by-passes where the lay of the land favours their construction, have been beneficial in America. The land over which the floods are permitted to pass has been resumed and leased back to the farmers with the right to flood. They have to take all the risk and in actual fact have lost very few crops. Really, they find the land is benefited by the floods and the gain in fertility makes up for the few crops lost.

A scheme which is advocated from time to time and which was revived recently in the press, is that an alternative outlet be provided for the Hunter River by a cutting from Raymond Terrace to Port Stephens. This scheme has been considered by many investigators over the last eighty years—no one who has studied the problem has, or could support it.

The cutting would be over twelve miles in length and as both Port Stephens and the river at Raymond Terrace are tidal there would be no natural grade in the cutting. It would depend upon a flood being in action to give it a grade to cause a flow and at maximum height that grade would be only one foot per mile. To carry one-half of the flood flow a channel 20 feet deep and 1,000 feet wide would be required. It would cost nearly £10m., the maintenance, because of siltation, would be heavy and the effect would be to lessen the duration of a flood but with negligible reduction in its height.

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BOOK REVIEWS

HATCHERY OPERATION AND MANAGEMENT

By E. M. FUNK and M. R. IRWIN

(*John Wiley and Sons Inc., New York,* 349 *pages,* $6.50.)

This is an American book written for American conditions where the poultry industry is much more highly organised than in Australia. For this reason alone, this book has many ideas to offer the Australian poultry farmer.

The book covers the whole range of hatchery operations from the beginnings of the specialised hatchery man, through selection of stock and poultry improvement plans, the actual handling of eggs and chickens, to the business end of marketing of chickens. The marketing sections have a great deal to offer local farmers as examples are given of record keeping, correspondence and guarantees to mention a few items. The sections on the actual handling of eggs and chickens are comprehensive, and make the book a worthwhile investment for the serious poultry farmer. The scale of operations described is greater than usually seen here, but the principles of strict sanitation and attention to all details from the supply of eggs, through incubation, to the final phase of satisfied customers, are universal.

"Hatchery Operation and Management" is a book that can be recommended to poultry husbandry advisers and to practical poultry farmers.

I. J. STEWART.

SOIL CONSERVATION AND ITS RELATIONSHIP TO THE FLOOD PROBLEM IN NEW SOUTH WALES

By L. G. KALESKI

It is suggested that there are four main approaches to flood mitigation:—

1. Forestation or reforestation of the steep lands at the top of the catchment.
2. Soil conservation work throughout the valley uplands.
3. Flood mitigation dams in the tributaries and the main river.
4. River improvement work, including river bank erosion control, snagging, straightening, dredging channels for increased capacity and levee banks.

This discussion will be limited to one phase of soil conservation, namely, infiltration and run-off, about which we have recently accumulated some interesting data.

It is obvious that floods result directly from two things. Firstly, a very big rainfall in a short time over a large area and, secondly, the fact that most of the rainfall on the uplands runs off. We cannot stop the rainfall but can we do anything to lessen the run-off?

During the February, 1955, flood in the Hunter Valley the Water Conservation and Irrigation Commission estimated that 1.5 million acre-feet of water flowed past Singleton in 5 days. Assuming the catchment above this point to be something less than 3 million acres, this is a run-off of half an acre-foot or 6 inches of rainfall from each acre in the Upper and Middle Hunter Valley.

During the four days February 23-26, 1955, the rainfall in this catchment averaged about 12 inches. The run-off over the whole area was high, reaching about half the total rainfall, but there is a good reason for this high percentage, which will be indicated later when considering rainfall and run-off data on Scone Soil Conservation Research Station.

We are gradually accumulating a mass of data on six research stations bearing on the amount and intensity of all rainfall and the infiltration and run-off from every rain on land of various slopes under various treatments such as cereal crops, fallow, grazing lucerne and improved pasture lightly and heavily grazed. The run-off is also calculated from the whole or major part of each station area up to 1,000 acres.

Research Station Records

Our six research stations are strategically placed, in respect of both land utilization and climate and the four northerly stations received the full force of this 1955 cyclonic disturbance from Queensland.

1. *At Wellington* 8.63 inches fell, of which 3.5 inches fell at intensities of more than 0.5 inches per hour. This is not severe rainfall. The fallow plots, of lengths of 132 feet between graded banks, gave the maximum run-off of 2 inches of rain or 23 per cent. of the total rainfall. This maximum figure of 23 per cent. run-off of the total rain, applies to a small proportion of the research station lands only. The amount of run-off from all the station lands has

L. G. KALESKI, B.Agr.Sc., is Chief Soil Conservationist with the Soil Conservation Service of New South Wales. *This paper was presented at a Symposium on "The Flood Problem in New South Wales", held by the New South Wales Branch of the Institute on April 29, 1955.*

been estimated as one-tenth of the 8.63 inches of rainfall or less than one inch. This would not have caused much flooding in the Macquarie.

2. *At Gunnedah* 8.99 inches fell in this rain period. There were 3.4 inches in 23 hours and a further inch fell in a little over half an hour at an intensity of 1.75 inches per hour. This is heavy but not torrential rain and not of as high amount or intensity as has been recorded at this station on several occasions since January, 1947. This 1955 rain came at a time when some banks and waterways were being re-designed and re-located and the exact measurement of the final discharge from the station, though not from any of the plot areas, was lost. The general report is that run-off from the station from 9 inches of rain was not great and damage to earth works slight.

3. *At Inverell* there is a recording of special interest. The rainfall was 9.44 inches and the maximum run-off from the final outlet was 355 cusecs representing 1.25 cusecs per acre. This is high but not unexpected, the reason being that these soils are black clays of basalt origin and our measurements have shown year after year that on soils of this nature up to 2 inches of high intensity rain can be absorbed very quickly on fallow and 3 inches on good grassland, but thereafter the rate of absorption is very low and rate of run-off correspondingly high. Perhaps one inch can be added to each of these figures by normal farm structural soil conservation work, but when more than four inches of rain falls in one rain period in the black belt some flooding of the Macintyre River can be expected.

4. *At Scone Station* 11.4 inches fell in a 4-day period, and of this only 0.4 in. was heavier than 1 in. per hour. This is not high intensity rainfall, yet over ½ cusec per acre maximum run-off was recorded. The reason is that in 32 days prior to this 11.4 inches, a previous 8.63 inches had fallen, resulting in the soil being saturated and all absorption structures being full. In 37 days there were more than 20 inches of rain. Despite the dense vegetation and low intensities the lands were full to capacity. Hence the high run-off during the last 11 inches in 4 days.

Measurements have been taken of run-off of all rain periods on the six Research Stations since 1940 and there are hundreds of these. I would like to give brief mention to a few.

In January, 1947, *at Gunnedah,* 595 points were received in 90 minutes. The whole of the station mechanical soil conservation work had just been completed. Everything flowed to absolute capacity but there was no damage on the Station. Below the Station, where a few years previously the railway embankment, highway and the boundary fence of the lower property had twice been washed out completely for lengths of 10 chains in much less rain periods, there was no appreciable damage, indicating greatly lessened run-off due to soil conservation works.

On the Wagga Station in December, 1947, a storm of 259 points in 40 minutes was registered, representing an average intensity of 375 points an hour for the duration of the rain. There was registered on the pluviograph a maximum intensity of 450 points an hour for 20 minutes. This is torrential rain also, and most valuable on new Research Stations. Stabilized structural work was undamaged. Water flowed down the main waterway at full width at a depth of 1 foot as planned and filled the final dam. The 30 feet wide grassed outlet from this dam leads via another waterway to a natural depression into the Murrumbidgee. It was at the outlet to the dam

Figure 1.

An absorption bank on a Namoi Valley farm decreases run off substantially.

that the unexpected happened as hail piled up across the outlet of the dam and sealed the outlet with a wall of ice 30 feet wide and three feet deep. As a result, freeboard was lost, the wall cut through and slight damage resulted at the final outlet from the Station. There was no other appreciable soil movement on the Station, whereas on adjoining lands gullying was severe and large quantities of silt were deposited on the flats. The run-offs from the bare hills to the south-east of the Station caused extensive damage to the railway.

In the Lachlan Valley where there were 11 floods in 14 months at Forbes during the late 1951-early 1953 period there was no run-off at all from the Research Station at Cowra. If the same treatment were applied, as I hope it will be, to all other farming and grazing lands in the Lachlan Valley, then the flood story must be radically altered.

In the Namoi Valley, Wongo Creek valley is 30,000 acres in extent. There are 24 landholders, all keen conservers, and a great deal of soil conservation work has been done there. In addition, the Service has built five little farm flood control dams around the main heads of the creek. These are kept empty by an outlet through the bottom of the wall.

Whereas five years ago this creek used to flow 12 feet deep and spill out erosion debris across the Namoi flats, in recent years there has been scarcely any flow in it at all and these have been very stormy years. In this 1955 flood rain period, the District Soil Conservationist reported that no damage whatsoever occurred to soil conservation works on the Keepit foreshores or the Baldwin Mountains area, from which Wongo Creek flows, and most of the rainfall was absorbed into the soil or stored on the surface.

Conclusion

There is a mass of other data on infiltration and run-off from small plots under various land uses, from larger farm areas of arable and grazing lands, variously grazed and improved, gradually building up to the effect of soil conservation measures on the run-off from whole creek valleys.

A reasonable broad interim conclusion is that in most parts of New South Wales adequate soil conservation work will result in trebling the amount of water that is retained on the farm following heavy rainstorms. This means that the flood mitigation engineer will receive that amount of water less to handle in the rivers. At the present time soil conservation work in various stages, is going on on 13,000 farms in the State.

It is a fair assumption that, in rain periods even of the highest intensities we have yet recorded, most, if not all, of the first four inches can be retained on the farms, under complete but standard farm soil conservation measures, installed by the farmer to protect his own lands and improve his own production. This means that in rain periods up to, say, 6 inches, soil conservation work on the farms is becoming a major flood mitigation measure.

However, in the big rain periods of 6 to 18 inches and particularly those of short duration, such as 24 hours, the effect of soil conservation will be progressively smaller as total rainfall exceeds 6 inches, and in these really big cyclonic rains then every flood mitigation measure as envisaged in the Huddlestone report of 1947 is essential, if any worthwhile control of our wild rivers is to be achieved.

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BOOK LIST

Notice has been received that the following books on agricultural topics have been published recently.

ADRIANCE, Guy W. and BRISON, Fred R.—Propagation of Horticultural Plants. 2nd. ed. *New York, McGraw-Hill Book Co. Inc.*, 1955, $6.50.

BAINER, Roy, KEPNER, R. A. and BARGER, E. L.—Principles of Farm Machinery. *New York, John Wiley & Sons, Inc.*, 1955, $8.75.

BENEKE, Raymond R.—Managing the Farm Business. *New York, John Wiley & Sons Inc., London, Chapman & Hall Ltd.*, 1955, $3.96.

CHEEMA, G. S., BHAT, S. S. and NAIK, K. C.—Commercial Fruits of India. *Calcutta, Macmillan & Co. Ltd.*, 1954, 30/- stg.

FERNALD, H. T. and SHEPARD, Harold H.—Applied Entomology. 5th ed. *New York, McGraw-Hill Book Co. Inc.*, 1955, $7.00.

GOODSPEED, Thomas Harper—The Genus Nicotiana. (v. 16 Chronica Botanica.) *Waltham, Mass., The Chronica Botanica Co.*, 1954, $12.50.

HILDRETH, Clifford and JARRETT, F. G.—A Statistical Study of Livestock Production and Marketing. (Cowles Commission for Research in Economics, Monograph No 15.) *New York, John Wiley & Sons Inc., London, Chapman & Hall Ltd.*, 1955. $4.50.

HORACE PLUNKETT FOUNDATION—Year Book of Agricultural Co-operation, 1955. *Oxford, Basil Blackwell*, 1955. 25/- stg.

SERVISS, George H. and AHLGREN, Gilbert H. Grassland Farming. *New York, John Wiley & Sons, Inc., London, Chapman & Hall Ltd.*, 1955. $2.96.

SHANNON, Ian—Rural Industries in the Australian Economy. *Melbourne, Cheshire*, 1955.

WAINE, Allan C.—Background to Beekeeping. *London, W. H. & L. Collingridge*, 1955. 15/- stg.

TOWN AND COUNTRY PLANNING AND FLOOD PROBLEMS

By DENIS WINSTON

From Egypt to China the history of civilization has been the story of the taming of the great rivers and the use of their waters for irrigation, navigation and power production. Australia is just embarking on this great task, which will require all her skill and energy for many years to come.

Floods have occurred since earliest Australian history, and will continue to occur. Forbes, for example, was flooded more or less severely 24 times in the 65 years from 1870 to 1935. Between 1850 and 1950 parts of Wagga were flooded no less than 51 times. It is worth remembering that the official site for the town of Kempsey was West Kempsey, which has never been flooded. The official site for Maitland was East Maitland, not West Maitland (the main centre) which has repeatedly suffered terrible losses.

Some kind of declared flood areas should be gazetted immediately, within which no building would be permitted. If this is regarded by some as an infringement of the freedom of the individual it should be remembered that the free individual is the first to call for help when a flood occurs. However, the negative approach of prohibiting building in certain areas is not enough. Positive measures are required to encourage new development in the right places and to transfer people from the declared areas with the minimum of loss. For this to take place adequate capital and a scheme of administration must be provided.

The first thing to do is to choose the best possible new town sites and then advantage should be taken from all we have learned in the past to lay out new townships in a really fine modern way. Here is a chance to bring good out of evil and benefit from disaster.

If the roads and services are put in by the local authorities and if certain of the public buildings, schools and so on are put in by the appropriate Departments, then homes, shops and commercial buildings will soon fit themselves into the new subdivisions, given proper financial assistance in one form or another.

An essential feature of a practical programme to deal with all flood problems is that it involves comprehensive planning and requires the co-ordination of the activities of different authorities, none of which is able by itself to see the whole picture. Water storage, irrigation, flood control, navigation, power production, mining, agriculture, industry and transport are only some of the things which have to be considered simultaneously in dealing with the problems of a great river valley. These various activities are all linked, yet their needs may be conflicting, requiring compromises to be reached which would be impossible for a single purpose authority, like a Water Conservation or Main Roads Department.

What appears to be needed is a new kind of comprehensive authority or commission to look at all the problems of the drainage basin of the river, and be able to conduct the climate and resources surveys, mapping and land use surveys, which are absolutely essential before any plans could be drawn up. Perhaps these

D. WINSTON, M.A., is Professor of Town and Country Planning with the University of Sydney. *This paper was presented at a Symposium on "The Flood Problem in New South Wales", held by the New South Wales Branch of the Institute on April 29, 1955.*

powers and responsibilities should be given to the new Regional Councils when they are formed.

The problems of the river valleys are all parts of the greater problem of regional and national planning, and the work of the all-purpose river authority should be integrated with regional and resources planning in general.

But in the final analysis the effective harnessing of the rivers and the development of the great Australian river valleys is also largely dependent upon the practical implementation of decentralisation policies which have long been incorporated into the platforms of every Australian political party, so far with little effect.

The greatest problem linked with decentralization is the political problem. It is very hard to divert large sums of money from the capital cities with their numerous voters to the comparatively voteless rural areas. Yet vast expenditure is involved and the work is far beyond the resources of the local authorities. Effective action therefore depends on co-ordinated planning from national to local levels.

The multi-purpose river authority of the kind referred to above would be an effective link between the too highly centralized State Government and the local authorities with their insufficient financial or technical resources to undertake major work. Its headquarters should be decentralized to an appropriate location in the region.

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SOME ECONOMIC ASPECTS OF THE FLOOD PROBLEM IN NEW SOUTH WALES

By J. RUTHERFORD

To grasp fully the economic problems raised by large-scale flood control, it is essential that we accept the fact that settlement on flood plains might always constitute a calculated risk. Engineering authorities assure us that something can be done to mitigate the effects of many floods, particularly nuisance floods, but it is doubtful if it will ever be technically or economically feasible to control all floods. Flood damage and the costs of flood mitigation must be regarded, therefore, as part of the price which a community must pay for the manifold benefits of settling on flood plains. Large-scale expenditure on flood mitigation should always be justified as far as possible in terms of the tangible benefits which are expected to arise from this investment.

Many people assert that floods should be controlled at all costs. However, from a national standpoint, flood mitigation is only one of the many ways of improving the welfare of our community. In this country, with a fairly full use of resources, money spent on controlling floods is, in most cases, money not spent on other forms of development. Investment in flood mitigation, therefore, will always compete with investment in other developmental projects. For this reason it is essential that a comparison be made of the benefit-cost ratios of investment in one form of flood control with (a) other forms of flood control, and (b) other forms of investment. In some cases, it will be impossible to make this type of comparison; for example, we cannot readily compare the merits of spending money on flood mitigation with expenditure on education. In addition, it will be impossible to estimate the ultimate benefits which might occur from any measure such as flood mitigation; short-term benefits might seem small, but ultimate benefits might prove much larger. Nothwithstanding these obvious difficulties, this type of economic analysis must be made wherever possible to ensure that scarce resources are employed in the best public interest.

Of course, it would be foolish to suggest, even if no flood control measure showed a favourable benefit-cost ratio, that money should not be spent on flood mitigation. It is universally accepted that a flood control programme is justified where the lives and social security of sections of a community would otherwise be in jeopardy. Measurable economic factors are only some aspects of the problem of flood control. However, it is still incumbent on us to ask the question: "How much can we afford to spend on flood mitigation in a particular area and what control measure can be justified best in terms of the measurable benefits?" A sound economic analysis of the problem will be required to answer this question.

Aims and Methods of Evaluation

An economic evaluation of projects for mitigation of floods in any region will serve the following functions:—

1. It will indicate whether the community is justified, on economic grounds, in spending money on the scheme.

J. RUTHERFORD, B.A., is Economics Research Officer with the New South Wales Department of Agriculture. *This paper was presented at a Symposium on "The Flood Problem in New South Wales", held by the New South Wales Branch of the Institute on April 29, 1955. The views expressed by the author are not necessarily shared by the Department of Agriculture.*

2. It will provide an estimate of the economic merits of alternative measures for mitigating floods in the region.
3. The analysis will provide a sound basis for determining how control measures should be financed. It will help to devise equitable ways of allocating costs between different areas affected by the proposed measures, and show to what extent local beneficiaries can finance all or part of the costs involved.

The steps involved in an economic analysis of the flood problem are:—

(a) *Estimating flood damage.* A comprehensive and detailed survey of flood losses over a long period of years is a basic pre-requisite of sound planning for flood mitigation. As far as I can ascertain, no complete studies of this kind have been made in Australia, although two studies recently made for the Macleay and Hunter valleys have provided very useful material. Many estimates have been made of flood damage in various areas, but they all tell an incomplete story. In particular they relate only to very recent history. To be of maximum value to the overall design of sound flood mitigation schemes, estimates of past flood damage should provide a sound statistical basis for assessing the likely *future* pattern of flood damage. At this stage, we know that floods have caused very serious losses in some years but we are still uncertain as to the more precise pattern of flood damage for any region over a long period of years. Therefore, I consider it imperative that we press on with the task of making such detailed assessments. Until this data is available, it will be very difficult to design sound schemes for mitigating floods and equitable measures for meeting the costs involved.

(b) *Relating flood damage to different degrees of flooding.* The next step in the economic analysis is to relate data for flood damage to different flood situations taking into account floods of varying severities. This will show the *direct benefits* we might expect if floods of certain dimensions were controlled. To this we might add any *indirect benefits* which can be expected and which are measurable. Of course many of these indirect benefits will be intangible although they will greatly influence final recommendations, particularly those affecting how flood control is to be financed. These indirect benefits will involve social and political considerations.

(c) *Benefit-cost ratio.* The final step in the economic analysis is to relate benefits to costs for any proposed flood control scheme. The benefit-cost ratio should always be an important factor affecting final recommendations. For example, the U.S. Federal Government will not finance any flood control measure unless it is satisfied that benefits will exceed costs.

Costs of Flood Mitigation

In the first place, there are the direct costs of erecting the necessary works. These are relatively easy to measure. However, where the constructional stages of a project extend over many years, some assessment of long-term changes in costs will have to be made. Of course there are other complex cost items. For example, certain losses will be sustained when a flood control dam is built. Land of some productive value will have to be resumed for the site and the dam may cause permanent or temporary flooding of large areas upstream from the dam site. Roads and even townships might also be affected in this way. Some attempt will have to be made to assess these losses. Very often flood control dams will provide the best measure of flood mitigation. However, such structures present a serious problem in that usually they are very expensive. Can such dams always be justified in terms of the benefits which they will bestow? Can a more reasonable, if less comprehensive,

measure of flood mitigation be achieved by less ambitious works?

Where a dam can serve two or three functions, including flood mitigation, only part of the cost need be matched against the benefits. In these circumstances, the dam is more likely to prove an economic proposition. However, peculiar conditions are required before it is possible to satisfactorily design multi-purpose dams.

Using conservative estimates of annual costs and liberal estimates of the value of land which might benefit, a number of dams proposed for some of the rivers in this State have been shown to be very costly. For example, an official report has recently shown that building two flood control dams on the North Coast would cost annually more than 8/- in the £ (unimproved capital value) of the land which might benefit from the dams. This suggests that it is very doubtful whether the net benefit to local and other citizens would equal, let alone exceed, the cost involved. Of course this is only an approximate measure. It is impossible to evaluate fully all short-term and long-term future benefits from any dam.

Whilst in some situations large flood control dams might appear to be unjustified economically this might not apply to all dams irrespective of location. Similarly, other measures for mitigating the effects of floods might have favourable benefit-cost ratios. Re-designing portions of towns, and the construction of levee banks, drainage channels and soil conservation measures will often come into this category.

Financing Flood Control

Where comprehensive works are required it is inevitable that Governments will bear much of the burden. However, serious consideration should be given to encouraging the maximum amount of local participation without undue embarrassment. Leopold and Maddock in a recent book—"The Flood Control Controversy"—have made out a good case in support of their contention that this should be done. In view of the great difficulties of measuring and getting agreement on benefit-cost ratios, they maintain that a more practical measure of the worth of any flood control measure is its worth to the beneficiaries. They argue that this worth is specifically calculable in the degree that these beneficiaries will provide a *proportion* of the costs. These authors argue that if we encourage a greater degree of local participation, this will give the direct beneficiaries a more intimate interest in schemes for controlling floods and will tend to "encourage a better segregation of worthy from less worthy projects".

Flood protection to rural and urban industries is, of course, a form of subsidy to these industries. Unless they are required to meet some of the costs of mitigating local flood damage, we might expect that further heedless occupation of flood hazard areas will occur—unless, of course, it is inhibited by non-economic forces. Equitable ways of allocating some of the costs of flood mitigation amongst local beneficiaries must be based on detailed assessments of the flood hazard in different parts of the flood plain. This will require a lot of research in future years.

Flood Insurance

In conclusion I want to make a few comments on the problem of flood insurance. Many people believe that flood insurance might offer a workable means of ameliorating the adverse effects of floods. In my opinion flood insurance is an unknown quantity. It requires a lengthy trial period before its merits and demerits can be assessed. Flood insurance presents a number of problems:—

1. Can we collect sufficient data on the flood problem to provide a sound actuarial basis for insurance?
2. Can such an insurance scheme be financed?

We need more data about the history of flood damage. I doubt whether our present knowledge for any river basin would satisfy the statistical requirement of a sound flood insurance scheme.

In respect of the financial problems posed by flood insurance, I think we can take a lead from American experience. Insurance authorities in that country have concluded that a large-scale flood insurance could not be financed by private enterprise. Flood damage does not occur evenly from year to year—it tends to bunch into a few years separated by periods of uneven length. Therefore, an insurance scheme would have to maintain very large reserves.

This does not rule out the possibilities of a flood insurance scheme subsidized in the early stages by Government funds which could, over time, gradually become self financing. As one American authority (Langbein, 1953) recently put it: ". . . the government stands to gain much from successful no-loss insurance. It would spare the tremendous public and private hand-outs that follow every flood, and it would avoid the considerable loss in tax revenues to the government. Flood insurance would provide the means whereby those on the flood plains would share the major burden of their damages and thereby provide a check to heedless occupance of flood-hazard land. . . . Flood insurance seems conspicuously needed to give some economic stability to threatened areas, and to provide a handle by which to grasp the problem of flood plain occupancy."

Assessing the differential risk problems throughout a flood plain area will present great difficulty—it has to be done so that insurance premiums can be levied in an equitable manner. This problem can be simplified somewhat by dividing a flood risk area into a few zones and treating the flood risks as fairly uniform throughout each zone.

In pointing out some of the economic problems associated with flood control it has been my intention to sound some words of caution. I hope that my remarks have not swollen the ranks of those who claim that Economics is a dismal science.

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PROCEEDINGS OF SYMPOSIUM ON "TRACE ELEMENTS"

PAPERS READ AT A SYMPOSIUM HELD BY THE TASMANIAN BRANCH OF THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE ON SEPTEMBER 2, 1955.

Trace elements have long been recognised as a limiting factor in agricultural production in certain areas of Australia. Although a considerable amount of work has been carried out by workers in various fields in Tasmania, no real effort had been made to correlate the information obtained, much of which was in the nature of unpublished reports. In view of this position, the Tasmanian Branch of A.I.A.S. conducted a symposium on trace elements.

While previous work has been of considerable benefit to Tasmanian agriculture and the economy of the State, the stimulus to research on the diverse aspects of trace elements in relation to agriculture provided by the symposium will lead to even greater benefits to the community.

The symposium was held on September 2, 1955, at the University of Tasmania and was attended by about 70 members of the Institute and representatives of scientific institutions and commercial interests.

In his opening address the Minister of Agriculture, the Hon. J. J. Dwyer, V.C., referred to the work done on Kangaroo Is. which he had observed in its earliest stages. On his second visit about two years ago he was amazed to see 100,000 acres sown to permanent pasture carrying two and a half sheep to the acre. After ten years of pasture a forty bushel crop of barley could be taken off. Similar results had been obtained on King Is., Flinders Is. and at Waterhouse in Tasmania, where bush run had been converted into pasture land capable of carrying 2-2½ sheep per acre. The mere fact that these areas could be ploughed and cultivated was a measure of the achievements of the scientists who had done the work on trace elements.

The Minister welcomed Dr. P. R. Stout, Head of the Department of Plant Nutrition at the University of Berkeley, California. Dr. Stout was responsible for much original research on trace elements, particularly molybdenum, which is of special interest to Tasmania. The Minister concluded by expressing his hope for the complete success of the conference.

Papers were presented by four members of the Tasmanian Branch of the Institute and one by Mr. R. J. Green, Deputy Chief Veterinary Officer of the Tasmanian Department of Agriculture. These papers are published below.

Following these papers, Dr. Stout delivered a talk on the researches which led up to the discovery of chlorine as a micronutrient element. This discovery arose from work originally directed towards a study of cobalt in which a set of chemicals was used which happened to be particularly low in chlorine with the result that symptoms of chlorine deficiency developed in tomato plants grown in culture solutions. The affected plants showed a wilting of the leaf blade tips and progressively chlorisis, bronzing and necrosis in areas proximal to the wilting. Severely diseased plants failed to produce fruit. Adequate chloride added to the culture media entirely prevented the disease and severely deficient plants resumed satisfactory growth after chlorine was supplied to the culture solution or injected into the stems.

A lively discussion followed Dr. Stout's paper. One of the main points discussed was the possibility of chlorine deficiency being found in the field. Dr. Stout pointed out that the amounts of chlorine used by plants are large, and since it is not retained by soils one can only conclude that it is applied annually and that it must come from the rain. Under these circumstances, he could only conceive of it becoming limiting in an area so far inland that there was not enough cyclic salt picked up from the sea coming into the area in rainwater.

APPOINTMENTS AVAILABLE

(See also page 44 and Inside Back Cover)

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

AGRICULTURAL LIAISON SECRETARY

The Agricultural Research Liaison Section is seeking to appoint a graduate in Agricultural Science for information, documentation, and technical administrative work, at 314 Albert Street, East Melbourne.

The Agricultural Research Liaison Section is endeavouring to facilitate the application of C.S.I.R.O. research results in agriculture by direct liaison between the Organization and State Departments of Agriculture. The appointee will be responsible for much of the Section's administrative work, including technical and other enquiries, documentation of research publications, correspondence and general control of office staff.

Applicants should hold a University degree in Agricultural Science or equivalent qualifications, with experience in field investigations or applications of scientific work in agriculture, or in agricultural administration.

Salary on commencement will be determined according to qualifications and experience within the ranges of:—

Senior Technical Officer, £1,353-£1,623 p.a.

OR

Principal Technical Officer, £1,723-£1,943 p.a.

Applications, referring to appointment number 117/19, should reach the Officer-in-Charge, Agricultural Research Liaison Section, C.S.I.R.O., 314 Albert Street, East Melbourne, by 6th April, 1956.

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

RESEARCH PLANT PHYSIOLOGIST.

LOCATION: Irrigation Research Station, Merbein, Victoria.

DUTIES: To conduct investigations on the physiology of iron in plants grown in alkaline soils, and on the physiology of the vine berry.

QUALIFICATIONS: University honours degree in science with botany as a major subject and research experience in plant physiology.

SALARY: Dependent upon qualifications and experience, commencing salary will be within the range of Research Officer, £1,263-£1,888 p.a.

Applications, referring to appointment number 490/56 and stating full name, place, date and year of birth, marital state, nationality, present employment, particulars of qualifications and experience, and of war service, accompanied by copies of not more than four testimonials, should reach the Senior Officer-in-Charge, Irrigation Research Stations, C.S.I.R.O., Merbein, Victoria, not later than 6th April, 1956.

INVESTIGATIONS ON TRACE ELEMENT DEFICIENCIES OF PASTURES IN TASMANIA

By D. F. PATON

Investigations into the effects of various plant nutrients have been carried out on pastures in Tasmania over a period of 30 years. However, it was the discovery in 1943 that certain pasture areas in Tasmania were deficient in molybdenum that created great interest in the subject of trace elements and this has been further stimulated by the development since the end of the last war, of large areas of poorer soils, many of which have been shown to be deficient in several of the essential plant foods.

In the more recent series of fertiliser investigations, two methods of approach have been employed—the pot culture technique and the small-plot field trial. In both cases the trial design has invariably been of the factorial type in which the treatments are applied both singly and in tion to supplying information of any combination. This type of trial in addi- interactions between treatments has the added advantage of allowing all nutrients (major and trace) to be studied simultaneously in the one trial.

The trace elements considered here are molybdenum, copper, zinc, manganese, boron and iron. The Tasmanian experience with each of these nutrients in relation to the growth of pasture species is as follows:

Molybdenum

Pot culture trials in 1942-43 (Fricke, 1943) and field trials in 1943-45 (Fricke, 1944, 1945) indicated that molybdenum deficiency in pastures was widespread in some soils of the North Midlands, North East and North West Coast districts. Following this work and the subsequent commercial production of molybdenum superphosphate in Tasmania, considerable areas in these districts were treated with molybdenum, often with outstanding results.

The more recent series of investigations commencing in 1948 have demonstrated further areas of molybdenum deficient country both in the above districts and elsewhere, viz., East Coast, Central and Southern districts. These results combined with farmers' experience (molybdenum deficiency in pastures had become so widespread that investigational work on farmers' problem areas is not normally undertaken until the farmer has at least tried molybdenum) have led to a rapid increase in the use of molybdenum superphosphate. The use of sufficient molybdenum superphosphate during the past three years to treat an estimated 200,000 acres of pasture is some indication of the extent of this deficiency.

On the North West Coast, molybdenum responses on pasture occur on most basaltic soils except the chocolate soils adjacent to the coast. In the North East the lighter red basaltic soils and the grey transitional soils are molybdenum deficient for pastures. Elsewhere in the State, most of the responses in trial work have been obtained on podzolic soils, usually those high in ironstone gravel. To date, no responses have been recorded in trials on the light sandy soils in any district.

Molybdenum deficiency in pastures is characterised by poor development of the clover species with consequent very low production of the associated grass species.

D. F. PATON, B.Agr.Sc., is Agronomist with the Tasmanian Department of Agriculture. *This paper was delivered at the Symposium on "Trace Elements", held by the Tasmanian Branch of the Institute on September 2nd, 1955.*

General paleness and stunting of the clovers, including subterranean, white and red clover are commonly seen on deficient areas.

Experimental work on molybdenum deficient soils at several centres has shown that good responses are obtained with dressings as low as 0.75 oz. of molybdenum per acre. Increasing this rate to 1.5 oz. per acre has given responses in some cases while increasing the rate beyond 1.5 oz. per acre has had no additional effect on pasture production in any trial.

The residual effect of such dressings (1.5 oz. molybdenum per acre) under grazing conditions has not been examined critically, but in field trials with annual cutting for hay, there has been no significant increase in pasture production with supplemental applications of molybdenum over a three year period. The present recommendation is to apply two paper bags (187 lb.) of molybdate superphosphate (containing approx. 1.5 oz. of molybdenum) no more than once every five years and this practice is followed by most farmers.

In the more recent series of topdressing trials on *established clover* pastures on a wide range of soil types it must be regarded as significant that in no instance has a significantly greater response been obtained to lime (at one ton per acre of ground limestone) than has been obtained with molybdenum (at 1.5 oz. per acre). Although on the existing evidence, it cannot be stated that equivalent responses to molybdenum will be obtained on all areas of established pasture where responses to lime have been recorded, there are indications that one of the main effects of lime on many Tasmanian soils is to increase molybdenum supply to the plant. Lime is, of course, essential on the more acid soils for *successful clover establishment* and in these instances, molybdenum has been without effect.

Figure 1.
The known distribution of trace element deficiencies in pastures.

Copper

Copper has been tested in field trials at some 60 centres throughout the mainland of Tasmania. Large responses in pasture growth have been obtained only on the acid humus podzols along the North Coast of the State. Indications of small copper responses have also been obtained in pot culture work on soils from the East Coast and from Bruny Island.

On both King and Flinders Islands, copper responses have been obtained in a large proportion of the trials put down at these centres. In addition to the acid humus podzols, deficient soils include the calcareous dune country on King Island and on Flinders Island, both neutral to alkaline heavy clays and moderately acid sandy soils with clay subsoils.

On the more acutely deficient areas, practically no growth of the sown pasture species, e.g., subterranean, white, red and strawberry clover is obtained in the absence of copper. Copper deficiency in the above legumes shows as a marked

general yellowing of the entire plant, necrosis of the leaf margins and a more upright habit of growth. Subterranean clover appears to be very susceptible to copper deficiency and often does not persist into the second year.

The usual rate of application of copper sulphate is 7-10 lbs. per acre. Amounts in excess of this figure have given no increase in production in any field trial, while on one grossly deficient area, rates down to 1 lb. per acre have given responses in growth equal to rates up to 14 lbs. per acre.

Evidence from several centres indicates a substantial residual effect to 7-10 lbs. of copper sulphate per acre. Thus on one area receiving 10 lb. of copper sulphate per acre in 1945, no response to an additional 10 lbs. copper sulphate per acre applied in 1951 has been observed to date. Similar effects have been obtained on the acutely copper deficient heathland soils near Smithton over a shorter period of 5 years. The recommended rate of 7-10 lbs. of copper sulphate per acre once every 5 years would, therefore, appear to be adequate for pasture production on most soils.

Zinc, Manganese, Boron and Iron

Over the past 7 years, zinc, manganese and boron have been included in approximately 80 field trials and some 20 pot culture investigations. A wide range of soils in most districts have been covered, but only in a few isolated areas have responses been recorded to any of these three elements. Iron has been tested in somewhat fewer trials and no responses have been recorded on any area. The implications are that with the exception of a few well defined soil types in isolated areas, deficiencies of any of these four trace elements in Tasmanian pastures are of little importance at present. Details of the areas responding to any of this group are as follows:—

Zinc

On two contrasting soil types on King Island—the calcareous dune country and the "plains" country, significant responses have been obtained to zinc. In each case, the response is obtained only in the presence of both phosphate and copper while on the very acid "plains" country, lime is also essential.

On the calcareous dune country the increases in pasture production with zinc have ranged from 200% at one centre to 30-40% at two other centres. No response to zinc was obtained in a fourth trial on this soil. In the "plains" country trial the increase due to zinc has been approximately 30%.

Plant symptoms of zinc deficiency have not been observed in any of these trials, the only effect being the reduction in growth of clover in the absence of zinc.

The recommended rate of application is 7 lbs. per acre of zinc sulphate. In the one trial on the calcareous country of King Island where two rates of zinc sulphate (7 and 14 lbs. per acre) were tested, a depression in growth was obtained with the heavier rate.

Manganese

The only significant responses recorded to date have been in two trials on a neutral to alkaline heavy clay soil on Flinders Island. Here also, the response to manganese was obtained only in the presence of phosphate and copper. The rate used was 14 lbs. of manganese sulphate per acre. No deficiency symptoms other than the reduction in growth were apparent.

Boron

No field responses, but in pot culture trials significant increases to borax have been obtained with subterranean clover with two soils from the Strahan area and one from Bruny Island. In each case, the soil is strongly acid (pH 4.5 or less) and some lime is necessary for satisfactory nodulation. Increasing the rate of lime has a depressing effect on growth in the absence of boron and a positive effect in the presence of boron.

In these experiments boron was used at a rate equivalent to 3½ lbs. of borax per acre. In the absence of borax, sub-

terranean clover developed characteristic symptoms. The older leaves were near normal in size, but showed some purple to red pigmentation. The younger leaves were pale, extremely stunted and malformed and with upturned yellow margins. The petioles of the younger leaves were greatly shortened. The severity of these symptoms increased with increasing rates of lime.

Boron toxicity effects have been observed on subterranean clover in both pot and field trials when rates of borax in excess of 10 lbs. per acre have been used.

Conclusion

While the emphasis in this talk has been on the trace elements, some mention should be made of the general necessity of other plant nutrients on most Tasmanian soils for satisfactory pasture production. Thus phosphate in sufficient amounts is needed on all areas, while on some soils, lime and/or potash are required in addition to superphosphate before the full effects of trace elements are obtained.

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NEWS ITEMS

VISIT OF INDIAN FARMERS UNDER COLOMBO PLAN

A group of fifteen Indian Farmers, the majority of whom are Agricultural graduates of Indian Universities, are on a six months visit to Australia under the Colombo Plan, to study our agricultural industries, farming methods, marketing and agricultural organisation generally.

The party arrived in Australia during November last and, after a short orientation period in Canberra, spent some weeks in New South Wales, and later in Victoria.

The party has now split into groups and the visitors will gain practical farm experience by living and working on selected Australian farms, attending farmers' refresher courses, field days and engaging in many other activities.

The visit is proving most stimulating to both the visitors and those with whom they have come in contact and should go a long way to promoting further understanding and goodwill between Australia and her great neighbour, India.

THE KNOWN DISTRIBUTION OF TRACE ELEMENT DEFICIENCIES OF PLANTS OTHER THAN PASTURES IN TASMANIA

By G. C. WADE

The plant pathologist is concerned with the diagnosis and investigation of plant diseases. This term covers by definition any departure from the normal growth of the plant, whether due to a parasitic agent, or to an unfavourable factor of the environment such as a deficiency of an essential trace element. For that reason plants showing deficiency symptoms are frequently submitted to us for diagnosis and, as a result, we have obtained some knowledge of the distribution of trace element deficiencies in Tasmania. It is my purpose to summarise this information. I have intentionally omitted any reference to deficiency disorders of pasture plants, since that has been dealt with by Mr. Paton.

Zinc deficiency occurs widely on fruit trees, particularly apples, in Tasmania, (Wade 1949a) and has been recorded in several parts of the Huon, Channel, Bruny Island, Tamar and Derwent Valley areas. Affected trees develop typical rosettes of small, narrow and often chlorotic leaves at the tip of some of the leaders, with resultant poor growth. Excellent responses have been obtained to zinc sulphate sprays in August, the response lasting for two or three seasons after application. Apart from the direct effect of the deficiency, the resultant dieback renders the trees susceptible to attack by the wood rotting fungus, *Polystictus versicolor*.

Manganese deficiency appears to be even more widespread and has been noted on apples in many parts of the Huon, the West Tamar and Channel districts (Wade 1950). It is present on apricots and peaches grown on heavy black soils in the Rokeby, Sandford, Cambridge and Bagdad areas. On all these trees the symptoms consist of interveinal chlorosis, without a marked reduction in leaf size, though the leaves of affected apples may be rather narrower than normal. In severe cases the chlorosis may be marked and the general growth of the trees obviously reduced. Good control has been obtained by a post calyx application of 4.4.40 manganese sulphate-sodium carbonate mixture. Rather less satisfactory results have been obtained with the same spray applied to apricots shortly after the "shuck-fall" stage i.e. when the remains of the blossom fall from the fruit.

Suspected manganese deficiency has been noted on hops in the Derwent Valley, raspberries in the Huon and Channel districts, and vegetables in the Hobart and Campbell Town districts. Chemical analyses showed a low manganese content, but the diagnosis was not checked by application of manganese.

Boron deficiency is very widespread and causes serious losses of swedes and turnips in many areas, particularly in dry seasons. It has been recorded on those crops in the Hobart, Launceston, Smithton, Strahan, St. Marys, New Norfolk, Ouse, Huon and Channel districts

Corky core of apples due to boron deficiency occurs in dry seasons in the Huon and Channel districts, and in the Tasman peninsula (Carne and Martin 1937). Considerable confusion exists in growers'

G. C. WADE, M.Aar.Sc., is Chief Plant Pathologist with the Tasmanian Department of Agriculture. *This paper was delivered at the Symposium on "Trace Elements" held by the Tasmanian Branch of the Institute on September 2, 1955.*

minds between boron deficiency and the dimple condition of "Granny Smith" and "Cleopatra," which is probably due to a virus disease. Similar confusion between boron deficiency and stony pit virosis of pears occurs.

Copper deficiency has not been positively diagnosed on crops other than pasture, but apples on a property at New Norfolk show symptoms suggestive of this deficiency. This orchard has not received a copper spray for several years, whereas the regular use of copper sprays on the vast majority of orchards in Tasmania would prevent the development of this deficiency. This orchard previously showed zinc deficiency, but after its correction the suspected copper deficiency symptoms appeared. The most conspicuous symptom is the orange-yellow colour of the bark.*

Iron deficiency has not been recorded on commercial properties, but occurs on peaches and some ornamental plants in home gardens in Hobart. The symptoms consist of extreme chlorosis of the young leaves, with the veins frequently remaining green after the remainder of the leaf has become chlorotic.

Molybdenum deficiency has been recorded in Tasmania on cruciferous plants, particularly cauliflowers (Wade 1949b), and on peas (Wade 1952) in addition to pasture legumes. Whiptail in cauliflowers has been recorded in many districts including Hobart, Launceston, Scottsdale, Campania, Huon, Channel, Cressy and the North West Coast. It has occurred on a considerable variety of soil types including the black chernozem-like soils of the Hobart area. The condition has been avoided by the use of molybdenum superphosphate, or cured by spraying with a 1 in 2,000 solution of ammonium molybdate.

The deficiency is responsible for the comparatively unthrifty growth of many pea crops on the North West Coast. The Greenfeast variety is much more susceptible to this deficiency than Canner's Perfection, and in 1951 many Greenfeast crops on the North West Coast were almost complete failures as a result of the deficiency (Wade 1952). Affected plants develop severe symptoms of nitrogen deficiency, due to the failure to develop adequate efficient root nodules.

Figure 1.
The known distribution of deficiencies of trace elements and toxicity of manganese in plants other than pastures.

Manganese Toxicity: Although this paper deals with deficiencies it may be of interest to record here that suspected manganese toxicity has occurred at Spreyton and Launceston. A Cox's Orange Pippin tree at Spreyton showed very poor growth and brown necrotic areas were present under the bark. The symptoms were suggestive of "bark measles" which has been attributed to manganese toxicity (Berg and Clulo 1946) and analysis of the twigs of the affected tree showed a manganese content of 260 p.p.m. The soil in which the tree was growing had a pH of 4.5. While this manganese con-

*Since the symposium these trees have responded to the application of a copper spray.

tent is high, Orton and Clulo (1950) found that the bark of affected Delicious apples contained between 372 and 798 p.p.m. of manganese. However, in view of the low soil pH it seems likely that manganese toxicity was responsible for the disorder. The other suspected manganese toxicity disorder occurred in lettuces at Launceston. The leaves were generally chlorotic with severe marginal necrosis. The leaves contained 650 p.p.m. manganese, and this figure gives support to the diagnosis.

In conclusion I would like to stress that the deficiencies recorded in this paper, have been brought to notice mainly by growers submitting material for diagnosis of disorders, and by chance observations obtained during visits to properties for other reasons. No thorough survey of crops for the presence of deficiency disorders has been conducted in this State, and there is no doubt that further investigation would extend the recorded range of such troubles in Tasmania.

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NEWS ITEMS

WATER RESOURCES SYMPOSIUM HELD AT NEW SOUTH WALES UNIVERSITY OF TECHNOLOGY

On the 29th and 30th November, 1955, a symposium was held at the N.S.W. University of Technology at Kensington, entitled *"The Water Resources of Australia, Their Control and Development."* Speakers who were authorities in their own field gave their views on a variety of subjects. The proceedings were published in full by the University, early in February 1956 and may be purchased for the sum of 10/- per set. Orders for sets of proceedings should be sent to the Registrar, N.S.W. University of Technology, Barker Street, Kensington.

About 250 guests attended this symposium, representing a variety of organisations. The discussion which followed the presentation of the papers was interesting and it was clear that there were widely differing views on some of the topics, and it was unfortunate that more time was not provided in the programme for discussion.

At the outset of the proceedings, Mr. J. Beale, M.L.A., made a special announcement that a Water Research Foundation of Australia was to be set up with the idea of promoting research into the water resources of Australia. For this purpose, it would seek to raise funds by inviting industry, government agencies and private individuals to become members of the Foundation. Varying grades of membership are contemplated, ranging from £50 to £1,000.

Mr. Beale stated that the Foundation hoped to initiate and further research into all aspects of the efficient use and control of the water resources of Australia, and that it will foster research and co-operate with Australian universities, C.S.I.R.O., research organisations, government departments and other agencies.

The announcement of the proposed Foundation was excellently received by the press and the public, and offers of financial assistance have already been received from industrial and agricultural organisations and individuals. Subsequently the Foundation announced the granting of a Research Fellowship at Sydney University in the subject of "Water Harvesting" and a Research Fellowship in the N.S.W. University of Technology in "The Efficacy of Land Treatment in Water Conservation and Flood Mitigation."

MICRONUTRIENT DEFICIENCIES IN SHEEP AND CATTLE AND THEIR DISTRIBUTION IN TASMANIA

By R. J. GREEN

Summary.

Of the micronutrients essential for normal animal health only cobalt, copper and iodine are known to be deficient in the diet of grazing animals in some parts of Tasmania.

Cobalt deficiency, which affects only ruminants, has for years been recognised on the coastal areas of King and Flinders Islands and at Goulds Country. It is now known that animals may develop cobalt deficiency on both King and Flinders Islands when grazing on areas other than the calcareous coastal soils. During the last three years evidence has been obtained that cobalt deficiency is of importance on some of the red soils of the N.W. Coast.

Copper deficiency, originally recognised on the coastal soils and black swamps of King and Flinders Islands, is now known to be wide-spread on both islands (like cobalt deficiency). This deficiency is relatively common in Circular Head and has been reported at various places on the N.W. and N.E. Coasts, on the East Coast and is suspected at some places in the Northern Midlands.

The results and distribution of the deficiencies are briefly discussed.

Introduction

Only three of the micronutrients have been studied in investigations made into mortality and morbidity or decreased production by sheep and cattle in this State.

While it is commonly accepted that other micronutrients are important or essential for efficient production, cobalt, copper and iodine are the only three on which any work has been done in Tasmania.

This paper is intended to present briefly an account of the syndromes observed and the evidence for assuming a deficiency of each element and the pattern of occurrence of these deficiencies within the State. The evidence is based not on research work, but on analysis, field observation and in some cases field experimental work.

It is obvious that from an economic viewpoint the loss of production resulting from clinical or subclinical deficiencies of cobalt and copper is very considerable; but inadequate facilities for analysis have made it impossible to attack the problem systematically—hence most of the observations are made only when the results of deficiency are recognizable clinically. Figure 1 shows only centres where clinical evidence of deficiency has been confirmed by analysis, the figures being definitely in the deficient range. There are numerous areas, particularly in the islands, and on the N.W. Coast where a diagnosis of deficiency on clinical symptoms has been confirmed by analytical figures in the borderline range, or by unequivocal response to treatment—none of these have been indicated, nor has any instance of where a clear cut clinical diagnosis has been given, but no analytical or experimental confirmation sought.

Deficiencies of zinc, manganese and boron, as far as is known, do not occur in grazing animals in Tasmania, although Paton (1955) records a pasture response to each. It is probable as Underwood (1949) says of Western Australia that the animal requirement of these elements is below that supplied by the pasture grown on areas which show a response in yield to treatment with the elements concerned.

R. J. GREEN, B.V.Sc., is Deputy Chief Veterinary Officer with the Tasmanian Department of Agriculture. *This paper was delivered at the Symposium on Trace Elements held by the Tasmanian Branch of the Institute on September 2, 1955.*

Cobalt Deficiency

Records of syndromes which were probably cobalt and/or copper deficiency in Tasmania, reported by Philp (1933), date back to 1855 when the first sheep and cattle were introduced to King Island. While scientists in Australasia and overseas were accumulating data on "coast sickness" or "bush sickness", field evidence of "coastiness" was so common on King and Flinders Islands and at Goulds Country that farmers in those areas had evolved a system of husbandry to control the condition.

Cobalt deficiency affects only sheep and cattle of the domestic animals, and is characterised by no specific syndrome other than unthriftiness and loss of condition. The animal loses its appetite and literally starves to death irrespective of the amount of pasture available. As would be expected the deficiency most affects those animals with the highest nutritive requirements, calves and lambs. In Goulds Country, there are areas where not one calf or lamb had been reared in living memory, and healthy adult cattle and sheep introduced from sound country would die within seven and five months respectively.

The ability of the animal to breed and produce is affected according to the degree of the deficiency. Affected cattle develop a depraved appetite and in sheep there is often a watery discharge from the eyes, a tender matted fleece and a pale skin colour. The incidence of cobalt deficiency varies from year to year and from one time of year to another so that if recognizable loss results in one year, there is likely to be at least reduced production in other years.

Lee (1949) records observations over a ten year period in which there was (not quoted here in chronological order) 30% lamb mortality in two years, 100% lamb mortality in one year, retarded growth of lambs in three years and no symptoms in the other four years. Legumes normally contain more cobalt than grasses grown on the same soils and the actual cobalt content varies with the stage of growth.

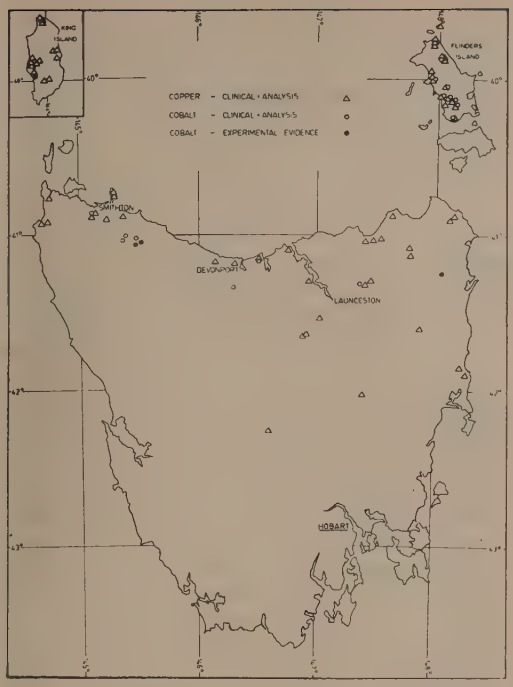

Figure 1.
The known distribution of copper and cobalt deficiencies in sheep and cattle.

The initial confirmation of the existence of cobalt deficiency in Tasmania was obtained by the use of licks, drenches and finally pasture topdressing at Goulds Country twenty years ago. The area affected is a small basaltic pocket 13 miles inland in the northern portion of the eastern coastal belt. The surrounding soil (classified as normal podsols with granite rocks intruding) appears to be sound.

Cobalt deficiency was confirmed at St. Helens by drenching, but until 1952 was not proved elsewhere on the mainland of Tasmania.

Philp *et al* (1939) and (1940), and Dumaresq and Wherrett (1948) had demonstrated the efficacy of drenches, licks and pasture topdressing in preventing "coastiness" at Ettrick on the west coast of King Island.

Field observations and analyses have indicated that the deficiency is not confined to the calcareous coastal soils of the two main strait islands, but that it is of basic economic importance to animal production over most developed areas of both islands.

In 1952, for the first time, evidence of the importance of cobalt deficiency was obtained on the N.W. Coast. Thain (1955) has reported widespread evidence of deficiency of cobalt (and copper) in cattle and sheep grazing on the red brown soils—a basalt soil belt which probably includes the majority of the farms on the N.W. Coast east of the Detention River. No cobalt figures for soil or pasture are available for this area, but liver cobalt values of 0.07, 0.05, 0.04 and less than 0.01 p.p.m., dry matter were obtained for sheep and anything below 0.07 p.p.m. is taken as indicating clinical deficiency.

Pasture values from Flinders Island were as low as 0.01 p.p.m., dry matter and again the normal range is more than 0.05 p.p.m.

No work has been done on the mainland of Tasmania to determine the longevity of pasture dressings, optimum rates or intervals—all most important considerations, and as yet insufficient analytical results are available to apply the findings broadly on the basis of soil types and enable general recommendations to be made.

Copper Deficiency

Cattle

Records of copper deficiency in this State are exactly as old as those of cobalt deficiency, because the original "coastiness" was a dual deficiency. Whereas information on cobalt levels can only be obtained from pasture or liver analysis, copper is present in about one thousand times higher concentration in liver and up to one hundred times in pasture and also in measurable quantities in red blood cells, so whole blood can be also used for analysis. This has made possible the collection of more information on the copper status of animals in Tasmania than on their cobalt status.

While cobalt deficiency is believed to be a simple entity, copper metabolism is influenced by the molybdenum and also by the inorganic sulphate content of the diet, so that in addition to simple copper deficiency there is a complicated type of conditioned copper deficiency to which no reference will be made in this paper.

The various syndromes of copper deficiency recognised in Tasmania are:—

Falling or Driving Disease of Cattle. Dumaresq (1952) has described this condition which he investigated on King Island in 1939. The disease seen on King and Flinders Islands, and it is believed, in Circular Head, occurs on rich clover country (reclaimed swamp) adjacent to typical copper and cobalt deficient coast country and is apparently identical with that originally described in Western Australia by Bennetts (1939 *et seq.*).

Cattle which may appear fairly healthy, but in which the myocardium is atrophied as a result of chronic copper deficiency, may suddenly drop dead—often the added excitement of driving or milking is sufficient reason. Deaths, which occur mainly in the lush spring months, reached the figure of 15 in one season on one King Island property.

As far as is known falling disease is confined to the black swamp soils. Liver copper values may be very low 4-50 p.p.m., D.M.; Blood and pasture copper may be low and constant scouring is usually a feature in the herds concerned.

Scouring and Unthriftiness in Cattle. These are seen on the lagoon country of both Strait Islands, in Circular Head and at various places on the N.W. Coast. Blood copper levels down to 0.12 p.p.m. have been obtained from affected herds. Production is reduced, butter fat percentage may drop, anaemia is obvious, unthriftiness and constant scouring may be evident. On one property on Flinders Island the scouring was so bad that dairying was discontinued.

Unthriftiness accompanied by low blood copper has been seen at Gladstone, Bridport, Pipers River, Bicheno, Waddamana and Cressy. It is possibly far more widespread in this State than is realised.

Sheep

Enzootic Ataxia. diagnosed on Flinders Island, at Bridport, Marrawah, Trowutta and Woolnorth and Trefoil Island, is a classical manifestation of severe copper deficiency. Damage to the spinal cord of the lamb occurs in utero when the copper status of the ewe is too low. At sometime between birth and three months the lamb will gradually develop paralysis of the hindquarters, be unable to follow its mother and die from starvation. Copper treatment of the affected lamb is useless.

"Steely Wool" has been observed in many clips from the Strait Islands and the mainland of Tasmania, particularly in the northern coastal belt. More easily recognised in Merinos, it probably accounts for a lot of the so-called "doggy" and "badly bred" wool.

Perhaps the most sensitive clinical indication of copper deficiency is the depigmentation of black wool—this has been seen at some places in Tasmania mainly as a banding or temporary lightening of colour. The tendency to loss of regular crimping and the characteristic harshness and lustre of steely wool is more commonly seen.

Unthriftiness in Sheep due to Copper Deficiency is widespread in the Islands in Bass Strait and suspected in some areas of Tasmania. Copper drenching experiments have not always given a clear-cut response.

Dual Deficiency of Cobalt and Copper.

In many of the areas where a deficiency of one of the two elements occurs, there is also evidence that the other is in short supply. This dual deficiency is common on the calcareous coastal soils and apparently also may be common on the basalt soils of the rich N.W. Coast farming district.

Iodine Deficiency

Congenital goitre in lambs was reported by Southcott (1945). The outbreak referred to occurred in the Huon Valley south of Hobart on alluvial river flats. Since then it has been observed in the Derwent Valley and at several places in the southern midlands.

Goitre appears prevalent in farm horses in Tasmania, and odd cases suggestive of iodine deficiency have been seen in calves in various districts.

Discussion

While the typical syndromes described above account for a great deal of economic loss, they are easily recognisable—hence usually corrected quickly. Borderline clinical deficiency, causing only unthriftiness and perhaps scouring and hence easily confused with and often masked by any other form of malnutrition, the effects of parasites or bacterial diseases like Johne's Disease, is probably a far greater cause of loss. Perhaps more important still is subclinical deficiency which merely reduces the value of production—cows do not give as much milk, cattle or sheep take longer to fatten or fail to do so, reproductive efficiency is impaired, sheep grow less wool or the wool lacks "quality".

The fact that, in borderline areas, the effects of deficiency may be evident only in occasional years further masks the problem. Soil treatment may influence the availability of these elements, or produce a "conditioned" copper deficiency by altering the molybdenum intake.

The total adverse effect on animal health and production in Tasmania is so great that the problem must be tackled on a broad basis of accurately determining the copper and cobalt status of animals grazing on each important soil type, and of the pastures grown on that soil; and then making recommendations for the treatment of that particular soil type.

This requires close co-operation between the soil scientist, agronomist, the veterinarian and the biochemist.

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APPOINTMENTS AVAILABLE

(See also page 32 and Inside Back Cover)

PUBLIC SERVICE
OF
SOUTH AUSTRALIA

Applications for the position set out hereunder will be received by the Public Service Commissioner, 31 Flinders Street, Adelaide, South Australia, until and including 29th April, 1956.

Applicants should state full names, address, date of birth, marital status, academic qualifications, practical experience, and give particulars of war service (if any). Copies only of testimonials should be submitted with the application.

The appointee may be required to contribute to the Government Superannuation Fund.

Agriculture Department
RESEARCH OFFICER
(ANIMAL HUSBANDRY),
KYBYBOLITE RESEARCH CENTRE

Salary Range: £900/£1,300 per annum (actual).

Duties: To carry out field research in Animal Husbandry with particular reference to problems of sheep and beef cattle production at the Centre and at the Struan outstation.

Qualifications: A degree in Agricultural or Veterinary Science is desired.

Accommodation: A house will be available for a married appointee at a rental to be fixed.

POSITION VACANT

Bureau of Sugar Experiment Station, Brisbane, require a Plant Pathology Graduate, preferably with experience, for investigations into sugar cane diseases, with Head Quarters at Brisbane. Salary and conditions will be disclosed to applicants who possess the necessary qualifications and experience. Apply in writing to Director, Bureau of Sugar Experiment Station, Brisbane.

PEDOLOGICAL ASPECTS OF TRACE-ELEMENT DISTRIBUTION

By K. D. NICOLLS

One of the aims of pedology is that by the study of the processes of soil formation we shall come to understand why each soil has its particular characteristics; why, for example, a particular soil is molybdenum deficient. We are then in a fair position to predict whether another soil may be molybdenum deficient, and if it is not deficient now, to say whether it is likely to become so with continued and intensifying land use. In Tasmania we are still opening up new areas, such as Montagu Swamp and the east coast of Flinders Island, where there is no local agricultural experience to guide us. We have to extrapolate from knowledge of other soils elsewhere which we believe will behave similarly. But probably at least as important as predictions for these new areas, is the diagnosis of possible sub-clinical deficiencies of trace elements on old-established areas, where plants or animals may make less than optimum growth without actually showing severe symptoms of deficiency.

Except in special instances, the soil is the source of trace elements for both plants and animals, so we expect correlations between the occurrence of trace element troubles and the distribution of one or other kind of soil. Two well-known cases from the literature are the high molybdenum "teart" pastures of Somerset which are restricted to soils developed on a group of calcareous rocks known as the Lower Lias (Lewis, 1943); and some cobalt deficient soils of the North Island of New Zealand which are restricted to two particular showers of highly siliceous volcanic ash (Grange and Taylor, 1932). Similar associations of soils with particular trace element troubles exist in Tasmania and we may instance the calcareous dune sands of the west coasts of King and Flinders Islands, with their attendant cobalt and copper deficiencies.

A soil may be subject to trace element disorders for one or more of three reasons. First, it might be derived from a parent rock which itself contained either too little or too much of the element in question. Second, in the processes of soil formation supplies of the element concerned may have been either lost altogether or locked up in an unreactive and unavailable form, or one element may be retained in undesirable proportion to another. Third, man by his agricultural activities may alter the supply of trace elements from the soil; either by altering the soil pH so that an element becomes unavailable or too available, and may be out of balance with others; or by intensive cropping which may exhaust the soil's reserves of an element; or by accelerating sheet erosion so that concentrations of an element in the surface soil are removed. The first two, the natural causes, should correlate with the soil pattern as revealed by the soil map, whilst the third case, man's interference, is less likely to do so and will more likely correlate with property or paddock boundaries. I shall deal here only with the first two causes.

Geochemical prospecting for ores of the heavy metals is based on the detection of unusually large amounts of the particular element in the surrounding soils. This is a case of inheritance by the soil

K. D. NICOLLS, B.Agr.Sc., B.Sc., is Regional Soils Officer for Tasmania with the C.S.I.R.O. at Hobart. *This paper was delivered at the Symposium on Trace Elements held by the Tasmanian Branch of the Institute on September 2, 1955.*

from its parent rock. Though it has often been inferred that *deficiencies* of trace elements in soils are due to deficiencies in the parent rocks, it is difficult to find in the literature any well-documented instance. The highly calcareous dune sands which commonly line west-facing coastlines in Tasmania and particularly the Bass Strait Islands may provide an instance. It has been argued for similar dune sands in South Australia (Thomas, 1938) that as these consist almost entirely of fragments of sea shells together with some silica sand, they must contain very meagre supplies of the heavy metals. Incidentally the cobalt content of sea water is given by Rankama and Sahama (1950, p. 290) as one part in ten thousand million. By contrast there are five parts per million of boron.

Whether or not the deficiency in the dune sands is inherited by the soil from the parent material, the deficiency of cobalt recently reported (Thain, 1955) on the red basaltic soils around Wynyard is almost certainly not an inherited one. Geochemically cobalt tends to follow iron and magnesium, and to concentrate in rocks rich in ferro-magnesian minerals, for example, basalt. Therefore in the absence of analyses, we should expect that the red soils (krasnozems) of the northwest coast are formed from rocks which contained relatively large amounts of cobalt. It seems that in the processes of soil formation cobalt must have been removed from, or rendered unavailable in, these soils.

It is evident that the more drastic the processes of soil formation are, or the longer they continue to act on the same body of soil material, the more likely it is that reactive constituents of the soil will be removed from the system while inert materials such as silica and hydrated iron oxides will accumulate. Removal from the system may mean either total removal by leaching to the ground water, or precipitation in some thereafter inaccessible form. Lateritic soils, podzols and podzolic soils, and basaltic red loams (krasnozems) have all suffered severe processes of weathering and leaching. We have in Tasmania considerable areas of each of these soils, and some, moreover, are very old.

Take as an example the lateritic soils of the Launceston Tertiary Basin, around Cressy and Longford, some of which are well known to be molybdenum deficient. The history of these soils may be reconstructed simply as follows:—Towards the end of the Pliocene Epoch, a large lake extended from north of Launceston south to Woodbury. It drained something of the order of a million years ago. Because of the flatness of the lake bed erosion could only be slow, and as the soil material was not being taken away by erosion it had perforce to suffer long-continued and drastic weathering and leaching. Nevertheless during the next half million years or so valleys had deepened to about 150 feet below the surface of the old lake bed. Then came a climatic change, as a result of which the rivers, instead of cutting their valleys deeper, started to fill them up, and river terraces up to five miles wide were formed in this period. The climatic pendulum swung again and the rivers commenced a new cycle of deepening their valleys, this time eating out some of the alluvium they had deposited. This cycle of scour and fill has been repeated several times, until today we have the position represented by Figure 1.

Figure 1.

Idealised section through a valley in the Launceston Basin. The names are those of the soil series characteristic of each situation.

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It will be evident that here we have a sequence of soils of decreasing age. The Woodstock and Cressy soils (Stephens, Baldwin and Hosking, 1942) are very old, perhaps nearly a million years. The Brickendon soils are also very old, though much younger than the Woodstock, perhaps half a million years. All of these are lateritic soils containing much ironstone gravel. The Brumby soils are much younger, something of the order of twenty or thirty thousand years. They are severely leached, but are not lateritic. The Canola soils are much younger still, five thousand years or less and in fact this floodplain is still building up. It seems that the occurrence of molybdenum deficiency should correlate with this soil pattern. Are all these soils in this sequence molybdenum deficient, or does molybdenum deficiency stop at the Woodstock and Cressy soils, or at the Woodstock, Cressy and Brickendon? If this question can be answered and the answer is that the deficiency does stop at one of the stages, we have a basis for prediction not only in the Launceston Basin but elsewhere, for similar soils and situations exist in the Derwent Valley and at other places in Tasmania.

In conclusion, it seems that if a more or less uniform extent of parent material is subjected to much the same soil forming processes for the same length of time, we must expect similar behaviour from the soil throughout. If a deficiency has been found on parts of it, it is likely that it will appear in due course all over it. If all the instances of deficiencies of trace elements known to agronomists and plant and veterinary pathologists can be brought together and correlated with soil maps, we shall be in a better position not only to understand the known occurrences but to predict where future ones may arise.

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COMMERCIAL ASPECTS OF TRACE ELEMENT FERTILISERS IN TASMANIA

By D. BERRY

As a supplement to other papers in this symposium it is proposed to discuss briefly the trace element fertilisers used in Tasmania at present, and to give some indication of the amounts dispatched annually to each of the various districts. The figures given, which refer to molybdenum, copper and cobalt only, represent total Tasmanian usage.

The first trace element fertiliser made in Tasmania was cobalt superphosphate in 1940. However, only 140 tons were made in 1940 and 1941, and then war time and subsequently post-war conditions precluded further manufacture of this fertiliser, and it was not made again until 1949. Molybdenum superphosphate was first made in 1945, and has been made each year since. Copper superphosphate and copper cobalt superphosphate were first made in 1954 following a request for their supply by the Land Settlement Division of the Agricultural Bank.

The method of production used is the wet mix method. In this the salt containing the trace element is mixed with ground phosphate rock before being mixed with sulphuric acid. This method gives a product of virtually unvarying trace element content, but is very wasteful of storage space. The demand for trace elements is low compared with the demand for plain superphosphate, and consequently only relatively small amounts of trace element fertiliser are made at a time. These are placed in piles in the storage shed, and space must be allowed around them to prevent contamination. In addition to this, the angle of rest of superphosphate imposes a limit on the height which can be expected from any given area of floor space, consequently much head room is wasted.

It is understood that most of the trace element fertiliser produced on the mainland is produced by the dry mix method in which the trace element salt is added to matured superphosphate just prior to bagging. This gives a product which is not as uniform in trace element content, but reaches a standard which is satisfactory for field use. Most, if not all, the results achieved by trace element use in Australia have been with a fertiliser made by the dry mix method.

Table I indicates the annual tonnage of the various trace element fertilisers despatched to various districts of Tasmania for each year from 1949 to 1955. The districts are those used in the organization of superphosphate distribution, and in the case of at least the North West, Burnie and Devonport districts it should give a reasonable picture of the ultimate destination of the fertilisers. The picture will not be as clear cut in the case of the Launceston and North West districts because of overlapping areas served by different distributors. Nor is much differentiation possible between the Midlands and other parts of the southern districts.

Types of Superphosphate

Molybdenum

This contains the equivalent of 2¼ lbs. of pure sodium molybdate per ton. The amount despatched before 1949 was approximately 1,900 tons. It would appear from the table that there may be a slackening in demand over the past two years in the North West, the Burnie and

D. BERRY, B.Agr.Sc., is Fertilizer Sales Manager with the Electrolytic Zinc Co. of Australasia Ltd., Tasmania. *This paper was delivered at the Symposium on "Trace Elements", held by the Tasmanian Branch of the Institute on September 2, 1955.*

TABLE I

Despatches of Trace Element Fertilisers to Districts in Tasmania, 1949-1955

Type of Superphosphate and Districts	AMOUNT DESPATCHED IN TONS						
	1949	1950	1951	1952	1953	1954	1955
Molybdenum							
Far North-West		29	401	175	720	613	733
Burnie	35	110	100	118	1,015	1,088	1,254
Devonport	28	209	150	239	1,263	1,320	1,836
Launceston & Nth.-East	642	1,153	1,175	773	1,835	2,038	2,826
Southern	78	309	253	270	989	1,066	1,552
Flinders Island					8	7	10
Tasmanian Total	783	1,810	2,099	1,575	5,830	6,132	8,211
Cobalt							
Far North-West		22	65	242	123	179	168
Burnie						19	86
Devonport						9	9
Launceston & Nth.-East	22	11	27	116	86	118	493
Southern	63	56	163	82	133	159	116
Flinders Island			2	71	118	370	290
Tasmanian Total	85	89	257	511	460	854	1,162
Copper and Cobalt							
Far North-West						79	205
Burnie							119
Devonport							13
Launceston & Nth.-East						56	334
Southern						94	80
Flinders Island						141	1,364
Tasmanian Total						370	2,115
Copper							
Far North-West						102	246
Burnie							14
Launceston & Nth.-East							114
Southern							8
Flinders Island						628	52
Tasmanian Total						730	434
Total Trace Element Superphosphate	868	1,899	2,356	2,086	6,290	8,086	11,922
Total Plain Superphosphate	41,988	59,691	54,163	63,372	57,887	67,640	70,918
Total of Both Types	42,856	61,590	56,519	65,458	64,177	75,726	82,840

the Devonport Districts, but it is doubtful if such a short period warrants this assumption. During these two years, there has been a reduction in the acreage sown to peas for canning and molybdenum superphosphate is often used as the fertiliser for this crop. Also, although there is still new land being brought into pasture, much of the pasture in this area has had molybdenum applied to it and will not need it again for a few more years.

Cobalt

In mixing this, cobalt oxide equivalent to 7½ lbs. of cobalt sulphate per ton is used. The amount of this fertiliser used prior to 1949 was approximately 190 tons.

Copper Cobalt

This contains 47 lbs. copper sulphate and cobalt oxide equivalent to 3½ lbs. cobalt sulphate per ton. It can be seen that the tonnage has had a marked rise but approximately 90% is at present supplied to the Land Settlement Division of the Agricultural Bank.

Copper

Copper superphosphate contains 75 lbs. copper sulphate per ton. This is not in great demand at present, and is mostly supplied to the Land Settlement Division.

Conclusion

Table I shows the amounts of plain superphosphate and trace element superphosphate used over the past seven years and shows the increased proportion of trace element fertilisers. If the present trend in demand for trace element fertilisers continues, the ultimate demand will probably be in the range of 25,000-30,000 tons per annum. However, factors which could affect this estimate, apart from economics are:—

1. An increase or decrease in the amount of new land brought into production each year.
2. Whether the applied elements remain in usable form or are fixed or leached, or are removed in crops or pastures with or without return to the soil.

This last factor could well be the most important as it would affect the frequency of application.

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WHEAT AND SHEEP PRODUCTION IN THE WHEAT BELT

By I. MOLNAR

Because of the difficulties experienced in the marketing of Australian wheat, it is desirable to show some of the limitations of any major change over from wheat to sheep in the wheat belt of Victoria.

Calculations of gross returns based on statistics have two major shortcomings. Firstly, statistics do not show the number of lambs produced on wheat farms. Secondly, any comparison between wool and wheat output per acre, based on statistics, would be misleading because farms in the wheat belt often carry sheep for only relatively short periods of the year.

This paper is based on production data obtained from farmers during surveys in the Dookie area (Molnar, 1955) and in the Northern Mallee of Victoria (Molnar, unpublished data). Its aim is to compare the returns *per acre* from wheat, wool and lambs on farms where these three commodities have been produced during two consecutive years. For further comparison, the experimental data for Rutherglen is also shown (private communication, Department of Agriculture, Victoria), where, unlike the other two areas, wheat is usually produced in rotation with ley without bare fallowing.

Data Used and Method of Computation

In the course of the survey of the Dookie area, reliable production data were obtained for 57 farms for the years 1951 and 1952, while in the survey of the Northern Mallee corresponding data were obtained for 39 farms for the years 1952 and 1953. From these two groups, those farms which, in both years, were producing wheat on more than 10% of the farm area, as well as wool and lambs, were selected for study. There were only twelve such farms in the Dookie group and only seventeen in the Northern Mallee. The selected Dookie farms had a total area of 10,463 acres and the Northern Mallee farms 31,887 acres. None of the selected farms suffered from climatic vagaries, pests or disease during the years under consideration.

The experimental data shown for Rutherglen refers to 1953-54 average production obtained on plots. The wheat yield refers to average wheat production on land which, prior to wheat, was under subterranean clover pasture for either 2 or 12 or more years. Wool and lamb production was obtained on pasture sown to Wimmera rye grass and subterranean clover with a cover crop in 1945. Since 1951 barley grass and spear grass have increased considerably at the expense of Wimmera rye grass.

The average annual and May-October rainfall in the areas covered by survey in the Northern Mallee is about 12 and 7 inches respectively, in the Dookie area about 21 and 13 inches, and in Rutherglen 23 and 13 inches. During the years for which production data were obtained the annual and the May-October rainfalls were about 2 inches above average in the Northern Mallee and Dookie areas, while in Rutherglen the annual rainfall was about 1 inch below average and the May-October rainfall was average.

I. MOLNAR, Ph.D., M.Agr.Sc., is Conservation Economist with the Soil Conservation Authority of Victoria.

TABLE I

Average production and stocking rates per acre on the selected farms in the Northern Mallee and Dookie areas and at Rutherglen.

	Northern Mallee 1952-1953 av.		Dookie 1951-1952 av.		Rutherglen 1953-1954 av.
	"Conventional"	"Adjusted"	"Conventional"	"Adjusted"	Experimental
Wheat per acre bush. .	15.1*	10.4	28.8*	19.2	25.9
Wool per acre†‡ lb. . .	1.7	2.6	5.3	7.7	23.7
Lamb per acre† nos.	0.09	0.14	0.31	0.44	2.70
Stocking rate† acres per dry Merino sheep . .	4.61	2.99	1.13	0.88	0.22

* These figures can be compared with the 1949/50-1953/54 average yields as shown by statistics for the parishes in which the selected farms are located. These are for the Northern Mallee 13.6 bushels per acre, for the Dookie area 24.1 bushels per acre and for the parishes around Rutherglen 20.9 bushels per acre.

The parishes concerned in the Northern Mallee are: Boulka, Daalko, Eureka, Gerahmin, Kattyong, Kulwin, Mittyack, Nyang, Ouyen, Paignie, Timberoo, Walpeup, and Woornak.

The parishes in the Dookie area are: Dookie, Currawa and Gowangardie.

The parishes around Rutherglen are: Chiltern West and Lilliput.

† Wool and lamb production and rates of stocking were calculated as described by Molnar (1955).

‡ Wool production does not include lambs' wool.

Production

Table I shows the two years average production of the farms and the experimental findings. The production of farms was calculated in two ways. The "conventional" calculation gives wheat yields per acre of sown area, and wool and lamb production per acre of the farm's area. The "adjusted" calculation gives wheat yields per acre of the area used in the course of wheat production, as distinct from the area sown, and wool and lamb production for the remainder of the farm's area. Thus wheat yields were computed by dividing the total wheat production by the acreage sown to wheat *plus* half of the acreage sown on bare fallow, while wool and lamb production were computed by dividing the wool and lamb production by the total farm area *minus* the area sown to wheat and half the acreage under bare fallow. (Land used as bare fallow is not ploughed up for about six months of the year and can therefore be classed as "pasture" land.) Wool and lamb production calculated this way does not take into account production derived from grazing wheat stubble and ploughed up fallow.

Relative Productivity

In Table II a comparison is made among the three areas to illustrate the relative importance of each as producers of wheat and sheep products. Lamb production was converted into wool production using price ratios for conversion.

Gross Return

Table III gives the gross return per acre, calculated by applying the highest and lowest prices of recent years (including the all time high 1950/51 wool price) to the adjusted farm production and to the experimental findings shown in Table I.

Net Return

The relative merits of the three areas as producers of wheat and sheep will be determined not only by the scale of physical output per acre and the relative price of the alternative products, but also by the relative costs of each kind of production in the different areas. For the construction of Figure 1 the "adjusted" farm production and the experimental findings (shown in Table I) were used to illustrate the net return per acre from sheep products (expressed as wool) and from

TABLE II

Relative physical productivity per acre in the Northern Mallee and Dookie areas and at Rutherglen.

	N. Mallee : Dookie	N. Mallee : Rutherglen	Dookie : Rutherglen
Wheat	1 : 1.8	1 : 2.5	1 : 1.3
Wool and Lamb—expressed as wool*	1 : 3.0	1 : 11.8	1 : 3.9

* Lamb production figures were multiplied by 6.6 for conversion into lb. of wool. The average of wool lamb price ratios at high and low levels is 6.6 (see Table 3).

wheat, within the range of "high" and "low" level of prices, with costs of production assumed at 50 and 75 per cent. of the gross return from each of these commodities. It was assumed also that costs of production change proportionately with changes in gross return.

Figure 1 shows that if, for example, the price of wheat is 180*d.* per bushel, and the costs of wheat production are 50 per cent. (i.e. 90*d.* per bushel), then in the Northern Mallee the net return from wheat will be £4 per acre, and if the costs of production are 75 per cent. (i.e. 135*d.* per bushel) the net return will be £2 per acre. Similarly to wheat if, for example, the price of wool is 90*d.* per lb., then with 50 per cent. costs of wool production the net return will be £2 per acre at Dookie, while with 75 per cent. costs of wool production the net return will be almost £4 per acre at Rutherglen.

Discussion

The wool production, shown for each area in Table I, is underestimated because lamb's wool has not been included in the figures. In the Northern Mallee and Dookie areas, cuts of lamb's wool were available only for late lambs, because fat lambs are normally sold unshorn. In these areas, whenever lambs were shorn, the cut per lamb was approximately 2 lb. Thus for the Northern Mallee the omission of lamb's wool causes practically no error because of the light output of lambs per acre. At Rutherglen, however, with almost three lambs to the acre, and with a cut of approximately 4 lb. wool per lamb, the omission of lambs' wool reduces the wool production by about 10 lb. per acre. Hence the relative physical productivity of Rutherglen, in terms of wool and lambs, is even greater than the figures indicate in Table II.

TABLE III

Average gross returns calculated per "adjusted" acre in the selected farms in the Northern Mallee and Dookie areas and based on experimental plots at Rutherglen.

Commodity	Price level	Northern Mallee	Dookie	Rutherglen
		£	£	£
Wheat	"High" (a)	7.80	14.40	19.42
	"Low" (b)	5.85	10.80	14.57
Wool and Lamb	"High" (c)	1.96	5.92	23.36
	"Low" (d)	0.57	1.70	6.64

(a) 180d./bush.; No. 16 pool (1952/53) } payment to farmers at railway siding.
(b) 135d./bush.; No. 12 pool (1948/49) }
(c) 132d./lb. wool of 56's, county of Moira origin, 1950/51 season.
918d./lamb of 36 lb. 1st & 2nd export quality, Newmarket price, 1953.
(d) 39d./lb. wool of 56's, county of Moira origin, 1948/49 season.
248d./lamb of 36 lb. 1st & 2nd export quality, Newmarket price, 1948.

In Table III the gross monetary returns obtained from wool are overestimated for the Northern Mallee, and underestimated for Rutherglen, because prices paid for wool originating from county Moira were applied to all wool production.

The choice of average wool lamb price ratios, for converting lamb production into wool to illustrate relative productivities does not affect the calculations materially. Variations in wool lamb price ratios would not alter the fact that the Northern Mallee is most productive in wheat and Rutherglen in sheep products, while Dookie is between the two.

Figure 1 shows that given a reasonable range of prices, wheat is always better

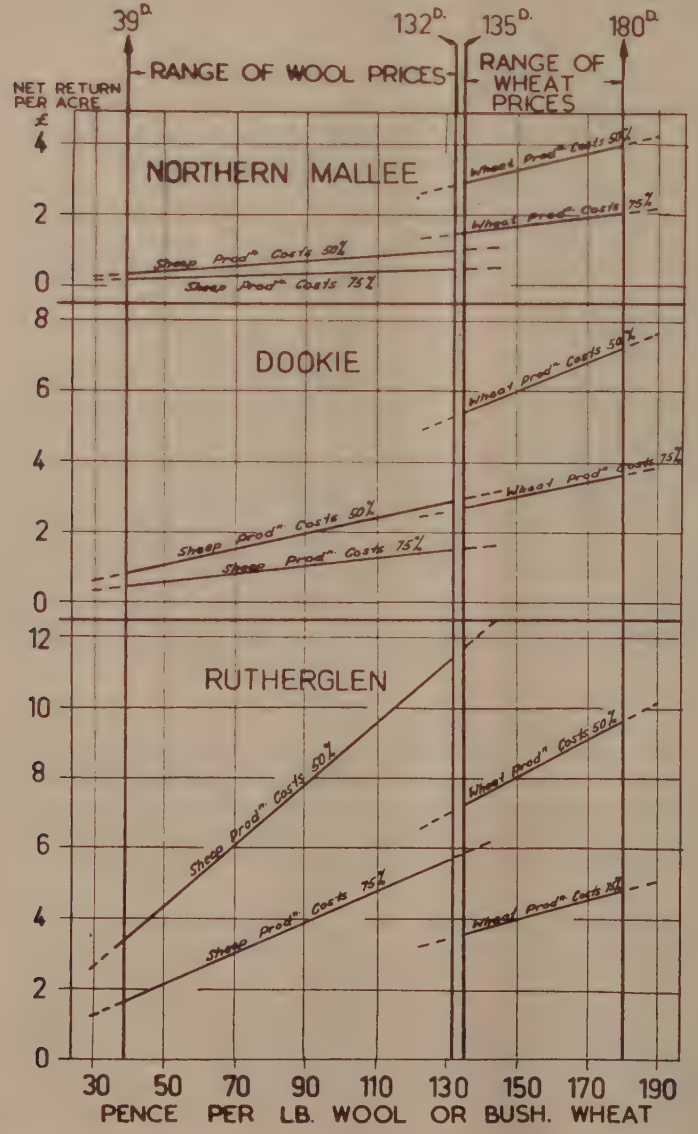

Figure 1.

Showing net return per acre when costs of production are 50% and 75% of the gross return from sheep products or wheat, at various commodity prices, in the Northern Mallee and Dookie areas and at Rutherglen. (1 lamb = 6.6 lb. wool.)

economically than sheep in the Northern Mallee and Dookie areas, at costs of production of 50-75 per cent. of the gross return, while at Rutherglen, under certain price conditions, sheep production is the better alternative. Since there are no reliable costs of production data available even for the wheat belt of Australia as a whole (Hodan, 1954), let alone regions within the State, comparisons can not be made at any specific combination of production costs. It is safe to assume, however, that costs of production (as per cent. of gross return) for wheat are considerably higher than for sheep. The costs of production of wheat at Rutherglen may not be markedly different from those in the Northern Mallee, because of the absence of fallowing and lower freight costs at Rutherglen. We do not know what portion of the production costs is made up by cultivation of the fallow and by transport expenses.

Should it ever become necessary to restrict wheat acreage, the yardstick for the imposition of restriction ought to be the relative agronomic and economic efficiency of alternative kinds of production per acre rather than per farm. In the Mallee, for instance, there is still no adequately tested pasture species capable of replacing cereals as a ground cover against wind erosion.* Until such a species becomes available only increased cereal fodder conservation plus hand feeding could increase the stocking rates without serious risks of erosion. Such practices are at the present the exception rather than the rule. With prevalent farming practices reduction in wheat acreage would mean larger areas under oats. But increase in oats acreage, primarily for grazing purposes, could increase the lamb output per acre in the Northern Mallee. The carrying of increased numbers of ewes, mainly on volunteer natural "pastures," for about six months of the year, including the most vulnerable summer months, would increase erosion risks. In recent years there has been a broadening of rotation in the Northern Mallee, and wheat is grown mainly once in every 3-4 years on the same land. A substantial increase in stocking could easily reverse the benefits of this improved rotation. It is a debatable point what difference there is in terms of wind erosion between overstocking and overcropping.

In any case, with existing farming practices, any feasible increase in stocking rates, based on a greater acreage of oats, could bring about an increase in sheep production (and possibly oats as well) which could not provide an adequate financial substitute for reduced wheat acreage unless, of course, there were radical changes in prices and costs of production.

The use of net return per acre, instead of per farm, for the measurement of economic efficiency and as one of the bases for restriction may cause economic hardship for some farmers. This would happen in areas where farm size is insufficient to provide adequate net return per farm from alternative kinds of production, though the net income per acre may be satisfactory. A case in point is the Dookie area where almost one quarter of the farms is less than 400 acres in size (Molnar, 1955). In this area, unlike that in the Northern Mallee, sheep production without wheat growing would be agronomically sound and would probably provide also a higher net return per acre than on farms in the Northern Mallee. Nevertheless, in the Dookie area, the discrepancy between the net returns from wheat and sheep per farm may reduce the total net income of the farmer to a level at which farming would no longer be economical for him. Under such circumstances it may even pay to subsidize farmers so as to provide them with adequate income and ensure that restrictions of wheat acreage will not force them to overstock their farms and thereby aggravate erosion risks.

If the wheat acreage is to be reduced then areas which are favourable to sheep

* In recent years the area under Barrel medic or "Barrel Clover" (**Medicago tribuloides**) has been rapidly increasing but the total acreage is still relatively small. It has to be proved yet that this plant can stand up to drought conditions.

production and where good pastures can be easily established should suffer the initial restriction or the greatest restriction of wheat acreage, e.g. Rutherglen. This would be realistic not only agronomically but also more in accordance with the way in which the guaranteed wheat price has been computed. If costs of wheat production are based on yield approximately of 11 bushels per acre, without any profit derived from "side lines," (Hodan, 1954), then areas like the Northern Mallee with such yields and with little side line income have a much more valid claim to remain in production than say Rutherglen with wheat yields which are about twice those of the Northern Mallee and where returns from sheep products are substantial. Further, a much more substantial reduction in wheat production will be achieved by the restriction of wheat growing in relatively small acreages in the high producing areas.

Conclusion

Should it ever become necessary to restrict wheat acreage, the sequence or the severity of restriction should be in the following order: Rutherglen, Dookie, Mallee, even if such an order may be somewhat hazardous from a drought risk point of view, the complete prohibition of wheat growing in defined areas would be easier to enforce.

Acknowledgment

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FLOWERING OF SKELETON WEED

By L. A. T. BALLARD

Summary.

Skeleton weed has been shown to be an obligate long day plant. It remains strictly vegetative when grown in an 8 hour day and the critical photoperiod lies between this value and 14.5 hours. It may be induced to flower by 10 consecutive exposures to a long day of 20 hours.

There is also some evidence of a cold requirement.

These facts are discussed in relation to the distribution of the plant in Australia.

Introduction

For reasons connected with attempted control measures, most investigations on the biology of skeleton weed (*Chondrilla juncea* L.) have been concerned with its vegetative development and regeneration, and little has been reported on its flowering behaviour. Apart from its intrinsic interest, such information may have practical significance in ways suggested below.

The normal development of skeleton weed, which commences as a rosette persisting until spring when a flower bearing stalk is formed, is suggestive of a pattern well established for many other plants. In such cases the increasing photoperiod is a major factor determining the initiation of floral primordia, and this may be coupled in greater or less degree with a specific, prior cold requirement.

The preliminary observations now reported provide evidence that such factors do, in fact, determine flowering in skeleton weed.

Methods

Seeds were obtained in the field (Canberra district) late in the summer of 1954 and stored in the laboratory till June 25, 1954, when they were germinated at 25°C. Seedlings were transferred to individual pots and cultured normally in the glasshouse under short day (S.D.), natural day (N.D.) and long day (L.D.) conditions. Until day 52 the S.D. was of 7 hours duration, thereafter 8 hours. Restriction of the normal day length was accomplished by drawing light-proof curtains over the plants at 3.30 p.m. or 4.30 p.m., and withdrawing them at 8.30 a.m. the following morning. The natural day at the commencement of the experiment was 10.4 hours (including that portion of the twilight estimated to provide an intensity of illumination of 2-3 ft. candles), rising to 15.2 hours on December 22 (day 180), and then declining. The L.D. was maintained at 20 hours throughout the experiment by appropriately supplementing the natural day, just prior to sunset, with incandescent illumination providing 50-100 ft. candles at plant surface.

The glasshouse was unheated during the winter, and partially cooled during the summer. For the first 6 weeks of the experiment the average minimum temperature was of the order of 4°-5°C., and the average maximum temperature 25°-27°C. Thereafter, the average minimum rose to the summer peak of 13°-15°C., and the average maximum to 27°-30°C., after which they declined. The temperatures of the S.D. and L.D. plants did not differ appreciably from that of N.D. plants except in two respects: (1) Until day 52 the night temperature of the S.D. enclosure was (for other experimental requirements) maintained at 20°-25°C. (2) Although the rosettes of the L.D. plants were not significantly heated by the lamps above, as the flower stalks elongated, and it became impossible to raise

L. A. T. BALLARD, Ph.D., M.A.(T.C.D.), M.Ag.Sc., is Principal Plant Physiologist with C.S.I.R.O., Division of Plant Industry at Canberra, A.C.T.

TABLE I.

Effect of photoperiod on development of skeleton weed. Time in days from sowing to the stage indicated.

Stage of development	Photoperiod		
	Short day (8 hours)	Natural day (10.4-15.2 hours)	Long day (20 hours)
First flower stalk	> 360	139	73
50% of plants with flower stalks	> 360	150	110
100% of plants with flower stalks	> 360	172	168
First open flower	> 360	216.5 ± 2.5	221.3 ± 4.0

the lamps further, some heating of the tips occurred. In some cases this may have adversely affected bud maturation.

Healthy growth was maintained throughout by frequent additions of culture solution. Records were maintained of appearances of flower stalks and open flowers.

Results and Discussion

The chief features of the results presented in Table I are—

(1) the clear cut response to short days. Under a photoperiod of 8 hours neither flowers nor flower stalks were produced and plants have been maintained under these conditions as completely vegetative rosettes for one year. The leaves of such rosettes are both narrower and more deeply lobed than those of the N.D. or L.D. series; (2) the acceleration of time of shooting with each increase in photoperiod. Contrary to expectation, the time of flowering is not similarly advanced, the difference between the N.D. and L.D. series in this respect being slight and not statistically significant. No substantial delay in flowering of L.D. plants is believed to have been occasioned by any possible tip injury, since more basally placed flower buds (which would not be subject to this effect) may open before apical ones, and in any event do so within a few days later.

From the dates of appearance of macroscopic flower buds in the N.D. series, the photoperiod necessary to induce flowering may be estimated to have a maximum value of the order of 14.5 hours. The present results, therefore, do not permit a more precise estimate of the true critical photoperiod than that it lies between 14.5 and 8 hours.

The data of Table II provide additional evidence on the acceleration of flowering by long days. On day 172 vegetative rosettes, which until then had been maintained on S.D., were divided into 3 groups. One group was transferred to L.D., where it remained, another received 10 consecutive exposures to L.D. and was then returned to S.D., and the third group was maintained on S.D. Neither shooting nor flowering occurred in the last group; but the plants of the other groups shot promptly and flowered, and flowering in the continued L.D. group was considerably in advance of the 10 L.D. group. Figure 1 shows the appearance of representative plants 35 days after the beginning of L.D. treatment.

TABLE II.

Effect of long days on the development of skeleton weed. Time in days after the commencement of long day treatment to the stages indicated. Treatment commenced 172 days after sowing.

Stage of development	Treatment		
	Continued short day (8 hours)	10 long days (20 hours)	Continued long day (20 hours)
Shooting	> 190	31.0 ± 2.0	31.0 ± 1.2
First open flower	> 190	120.0 ± 5.1	81.3 ± 3.3

Senescence of the rosette leaves of a plant normally occurs shortly after production of the flower stalk; but this did not happen in the plants receiving only 10 L.D. Moreover, the leaves on the flower stalk were more numerous and considerably larger than usual. This continued vegetative habit of growth, together with the delay in flowering, suggest that 10 consecutive cycles (of 20 hour photoperiod) is close to the minimum necessary to induce flowering in skeleton weed. At other photoperiods a different minimum number of cycles required for induction would be expected.

The evidence is thus substantial that the flowering of skeleton weed is under the control of photoperiod. Comparison of some of the times required to attain open flowers suggests a cold requirement also, although the evidence on this point is not direct.

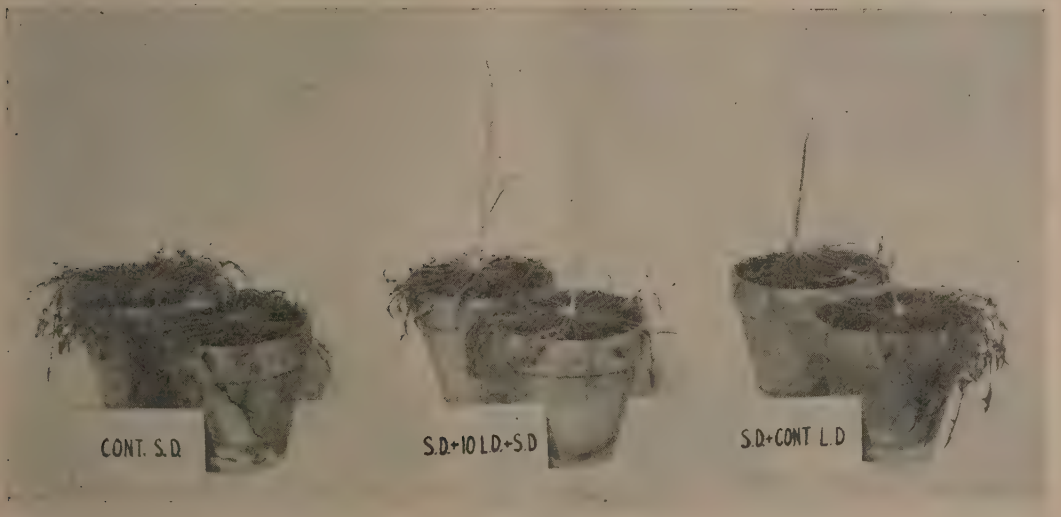

Figure 1.

Effect of long days on flower stalk development of skeleton weed. Cont. S.D. = continued short day (8 hours); S.D. + 10 L.D. + S.D. = 10 cycles of long day (20 hours) and return to short day; S.D. + Cont. L.D. = continued long day (20 hours). 35 days after commencement of treatment.

Low temperatures are known to accelerate flowering of long day plants by two distinct mechanisms (a) that whereby a given length of day is the more efficient the lower is the dark temperature with which it is associated (Lang and Melchers, 1943); (b) that comprising the process of vernalization.

The first comparison available is between glasshouse plants subjected to continued L.D. early in the season when temperatures were low (Table I, column 4) and later in the season when temperatures were higher (Table II, column 4). The operation of (a) above should lead to earlier flowering of the former, whereas comparison of the times in Tables I and II will show they required 140 days more than the latter to attain the stage of first open flower. Since the earlier treated plants experiencing the lower temperatures were seedling rosettes and the later treated plants experiencing the higher temperatures were mature rosettes, part of this delay must be ascribed to the time required for the seedling rosettes to become perceptive to photoperiodic stimulation (i.e., "ripe-to-flower"). It is improbable that 140 days should be required for this, and the more probable explanation is that the young rosettes required vernalization before being able to respond to the long days, while the older rosettes had already achieved vernalization before exposure to long days.

The second comparison available is between plants under N.D. in the field and in the glasshouse. Representative plants of each group on day 146 (just prior to the main shooting in the N.D. series), together with representative plants taken from the field in the near vicinity, are shown in Figure 2. At this date 97 per cent. of N.D. field plants had shot and were much branched, compared with 6 per cent. N.D. glasshouse plants, and 73 per cent. L.D. glasshouse plants. Al-

Figure 2.

Effect of photoperiod on development of skeleton weed. Plants 146 days old. S.D. = short day (8 hours); N.D. = natural day (10.4-15.2 hours); L.D. = long day (20 hours). Representative plants from the field under natural day are shown at the right.

though the field plants probably commenced their seasonal development somewhat before the glasshouse experiment began, it seems that this alone can scarcely account for the considerable relative earliness observed, which must then be attributed to the effects of the summation of the lower temperatures experienced by the field plants. Here, the operation of (a) above *must* contribute to the earliness of the field plants, and the intra-glasshouse comparison made above suggests (b) does also.

While such information as is discussed above may scarcely be expected to lead to control of skeleton weed in its vegetative stage, it contributes to an understanding of the factors determining its life cycle—a feature on which the need for more information has recently been stressed (Weed Control Conference, 1954). Such information, however, is directly relevant to considerations of dispersal and distribution, since skeleton weed is spread by seed.

A recent survey shows that skeleton weed is distributed in New South Wales as far north as latitude 32°S, and is apparently stationary on this front. On the other hand it appears to be spreading through the Mallee district in Victoria into South Australia (personal communication, R. M. Moore, and C.S.I.R.O. Annual Report, 1953).

Although it is recognized that additional factors may be operating, it is instructive to enquire to what extent this pattern may be interpreted by the facts presented above. The effective photoperiod at latitude 32°S. ranges from 10.1 to 14.9 hours, and small changes in these values at lower latitudes would not be expected to produce limiting photoperiods. Increasing temperatures (particularly night temperatures) may then be setting the limit. At all events the greatest spread of infestation currently observed, is towards regions whose climatic factors would, on the present analysis, favour flowering, i.e., increasing photoperiods, and decreasing temperatures operating by both mechanisms mentioned above. Moreover, any explanation of distribution need not be sought entirely in terms of the absolute presence or absence of flowering. Since skeleton weed is sensitive to competition the operation of any factor tending merely to retard its flowering would place it at a disadvantage, and *vice versa.*

Skeleton weed presents a uniform appearance in the field which would agree with the view of those who hold it reproduces apomictically. However, there is no firm evidence whether or not strains exist, differing in their physiological response to these stimulii. Nor does the present work offer any evidence on the behaviour of plants arising from perennial root stocks, as opposed to that of plants arising from seed. The above tentative analysis can thus only be applicable to the material investigated; but the questions raised suggest that a closer delineation of the effects of such environmental factors would be profitable.

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SELECTION FOR CHAETA NUMBER IN DROSOPHILA MELANOGASTER

By G. C. TANEJA

Summary

Selection for higher Chaeta number on the 5th abdominal segment of the *Drosophilia melanogaster* was practised for 10 generations. Selection for lower Chaeta number was started from the 5th generation of selection for higher Chaeta number, and was continued for nine generations. A line without selection was commenced from the 5th generation of selection for higher Chaeta number, and was continued for 6 generations.

Data collected on the above 3 lines of breeding were analysed and the results clearly indicate that:—

(i) In the line of selection for higher Chaeta number, up to the 5th generation, the mean values increased and the phenotypic variance decreased. After this, the means and the variances remained unchanged. Selection for lower Chaeta number did not make a significant advance since this line was started from the high line (5th generation) at a stage when no further advance could be made even for higher Chaeta number.

(ii) Absence of response to selection, both in the high and low lines, was found to be associated with low heritability. Selection had, therefore, reduced the genetic variability.

(iii) When the response to selection ceased after the 5th generation of selection for higher Chaeta number, a line of random breeding was started. This line did not return, at any time during the course of six generations, to the level of unselected population. This line, however, tended to stay between the lines of selection for higher and lower Chaeta number. Permanent changes in means and variances brought about through selection in the high and low lines of selection for Chaeta number, are clearly demonstrated by comparing them with those of this line.

Introduction

Mather (1941, 1942, 1943 and 1949) and Mather and Harrison (1948) studied the effect of continuous selection on Chaeta number in Drosophila. This experiment is designed on similar lines but is intended to present the effect of continuous selection on mean values, phenotypic variance and heritability of Chaeta number in *Drosophila melanogaster*.

Method and Material

The experiment was started with ten pairs of flies (*Drosophila melanogaster* O.R. stock) obtained from the Animal Genetics Section of the Commonwealth Scientific and Industrial Research Organization, Sydney. A mutant stock of the same species (white eye) was used as a control.

Flies were reared in half pint cream bottles containing about $\frac{3}{4}$" depth of standard agar, corn meal and treacle medium. The temperature of the incubator used for rearing the flies was 25° ± 1°C.

The ten pairs of flies, after mass mating in a culture bottle for three days, were transferred daily to new bottles over five days, laying eggs in each bottle for 24 hours.

Chaeta number on the ventral surface of the 5th abdominal segment of each sex were counted. On all the flies emerged, the chaetae were counted every day from each bottle for 4 days. After counting and sorting the flies according to their chaeta number for 4 days, 10 female and 10 male flies with highest or the lowest chaeta number were taken and put together for three days for mating. These ten pairs constituted the parents for the next generation.

To start with, the selection was made for higher chaeta number but, after 4 generations, selection for low chaeta number was also made from the high line. (As far as possible the corresponding generations of high and low lines were always raised side by side in the incubator.) Later on, as more time could be spared, a line without selection was set up from the high line.

G. C. TANEJA, M.Sc., B.V.Sc., is a postgraduate student with the Department of Physiology, University of Queensland.

Control.—Two types of controls were maintained.

(1) Flies from one of the bottles from which the experiment was started were maintained throughout the experiment without selection to act as a control.

(2) Ten pairs of mutant flies (white eye) were mass mated for three days in a culture bottle. Similarly, ten pairs of "normal" flies were also mass mated for three days in a separate culture bottle. From these cultures, 8 "white eye" and 2 "normal" female flies were put together in another culture bottle where they laid eggs for 2 days. When the flies from these bottles emerged, "white eye" and "normal" flies were separated and the chaeta number of 25 female and 25 male of each of "white eye" and "normal" were counted.

"White eye" stock was maintained throughout the experiment and no selection was made from them.

Later on, during the 11th generation of selection for high chaeta number the female flies from these generations, after they were mass mated for three days, were put together with already mated "white eye" flies in the same ratio for two days and the chaeta number of their progeny counted.

Experimental

A. High and Low Lines

1. *Mean Values*

(i) Mean chaeta number in the High and Low Lines of selection.

TABLE I.

Mean Chaeta Number in the High Line.

Generation number	female		male	
	No. counted	mean*	No. counted	mean*
HSO†	258	19.36±0.38	237	17.78±0.35
HS1	330	20.17±0.24	371	18.36±0.24
HS2	120	21.26±0.18	101	19.07±0.42
HS3	107	21.17±0.23	103	19.42±0.23
HS4	142	19.91±0.31	162	18.00±0.17
HS5	263	22.37±0.19	217	20.16±0.17
HS6	301	21.94±0.18	311	20.00±0.15
HS7	337	21.84±0.34	318	20.10±0.17
HS8	171	22.21±0.24	160	20.08±0.25
HS9	126	21.82±0.14	140	19.77±0.24
HS10	167	22.69±0.29	160	20.21±0.16
11th‡	10§	22.40±0.58	17§	20.70±0.45
12th‡	125	21.76±0.37	125	19.72±0.20

*Average of five cultures.
†H.S. = Selection for high chaeta number.
‡No selection.
§Smaller number due to growth of fungus in the media.

Mean chaeta numbers for high and low lines of selection are given in Tables I and II, respectively.

(ii) Estimate of selection for higher chaeta number.

There was no important change in the mean chaeta number in the control (mean chaeta in 11th generation being 19.40 ± 0.30 and 17.50 ± 0.32 for the female and male respectively) while the mean chaeta number in the high line had increased by the selection.

The total amount of progress reached in the high line was estimated by comparing the mean chaeta number (average of the two sexes) of the "normal" and "white eye" in HSO and HS11 as given below:—

Mean cheata number of "white eye" in HSO = 18.04
Mean cheata number of "normal" in HSO = 17.48

Difference .... = 0.56 . . . . . (A)
and again,
Mean cheata number of "white eye" in HS11 = 21.88
Mean cheata number of "normal" in HS11 = 19.94

Difference .... = 1.94 . . . . . (B)
Estimate of total progress reached .. .. = A — B = 1.38 Chaeta.

TABLE II.

Mean Chaeta Number in the Low Line.

Generation number	female		male	
	No. counted	mean*	No. counted	mean*
LS1†	261	22.08±0.21	231	19.69±0.20
LS2	320	20.55±0.31	354	18.90±0.20
LS3	325	20.73±0.16	307	19.34±0.16
LS4	125	20.64±0.17	125	19.05±0.14
LS5	137	20.26±0.13	132	18.65±0.13
LS6	186	20.63±0.12	187	18.87±0.12
LS7	131	20.75±0.15	130	18.99±0.15
LS8	89	20.45±0.18	83	18.25±0.15
LS9	18	22.10±0.40	19	19.30±0.35

*Average of five cultures.
†LS = Selection for low chaeta number.

(iii) Fitting of regression lines to the mean chaeta number.

(a) High line: The mean chaeta numbers of the two sexes were averaged for each of 13 generations. A linear regression of mean chaeta number (y) on their generation number (a) with the following equation was fitted:—

$$y = 19.1969 + 0.1877\ a.$$

The regression coefficient of 0.1877 ± 0.0428 was found to be highly significant ($t_{11} = 4.386$, P1% = 3.106).

Since the data suggested that there is no advance in the second half of the selection, the best fitting line may take a curvilinear shape. A parabola with the following equations was then fitted to the points:—

$$y = 18.1959 + 0.5881\ a - 0.0286\ a^2.$$

(a = generation number, y = mean chaeta number.)

The results of the analysis are presented in Table III.

TABLE III.

Results of Analysis of Regression of Mean Chaeta Number on Their Generation Number.

Source	d.f.	S.S.	M.S.	Variance ratio
Linear Regression .	1	6.3700	6.3700	18.902
2nd degree term ..	1	1.6016	1.6016	7.606
Residual	10	2.1056	0.2156	

P5% = 5.12 d.f. 1, 10.

Table III shows that the deviation from linearity was significant as tested by the ratio of the variances due to second degree term and the residual variance. It, therefore, indicates that the mean chaeta number did not rise linearly but followed a curvilinear path due to absence of response to selection in the second half of the selection period.

As these figures are based on the weighted mean values of the two sexes for 13 generations (HSO to 12th generation) they include the last generation resulting from the mass mating and the second last generation consisting of only a small number of flies. It was therefore decided to find out the trend of the regression of mean chaeta number on the generation number excluding the last two generations. Thus the following equation was calculated:—

$y = 18.9597 + 0.2393\ a$ (y = mean chaeta number, a = generation number).

The linear regression coefficient of 0.2393 ± 0.0501 was still highly significant. ($t_9 = 4.776$, P1% = 3.250.)

The following equation was solved for the curvilinear regression:—

$$y = 18.2083 + 0.5861\ a - 0.0289\ a^2.$$

The results of the analysis of the regression are presented in Table IV.

TABLE IV.

Results of the Analysis of Regression of Mean Chaeta Number on Their Generation Number (HSO to HS10).

Source	d.f.	S.S.	M.S.	Variance ratio
Linear regression .	1	6.2991	6.2991	22.6831
2nd degree term ..	1	0.7164	0.7164	3.2140
Residual	8	1.7289	0.2229	

P5% = 5.32 d.f. 1.8.
P1% = 10.56 d.f. 1.9.

Table IV shows that although the deviation from linearity is not significant, the possibility of the curvilinear regression cannot be ruled out because the "*F*" values are not very far from the 5% level of significance. On the other hand, it may be suggested that although during the last few generations there was no advance in the mean chaeta number, there was a tendency towards rising

TABLE V.

*Results of Analysis of Variance.**

Generation No.	d.f.	M.S. Bottles	d.f.	M.S. Residual	F
		High Line			
HSO	8	32.709	485	4.082	8.013†
HS1	8	20.030	691	3.622	5.530†
HS2	7	11.269	212	3.172	3.553†
HS3	8	6.239	200	2.700	2.311†
HS4	8	8.964	294	1.943	4.613†
HS5	8	8.228	470	2.692	3.565†
HS6	8	6.581	602	2.505	2.627†
HS7	8	23.800	645	3.004	7.920†
HS8	8	9.840	321	2.152	4.572†
HS9	8	5.178	256	2.383	2.173‡
HS10	6	8.332	319	2.597	3.208†
		Low Line			
LS1	8	12.056	482	3.269	3.688†
LS2	8	11.641	664	2.568	4.533†
LS3	8	10.586	622	2.503	4.229†
LS4	8	3.484	240	2.727	1.278
LS5	8	2.793	259	2.417	1.156
LS6	8	2.721	263	2.890	0.942
LS7	8	1.813	251	2.992	0.605
LS8	7	2.579	164	2.472	1.043

* = Both sexes combined

† = Significant at 1 per cent. level.

‡ = Significant at 5 per cent. level.

mean chaeta number and if the selection had been continued, the mean chaeta number may have been increased. This point further gains evidence for the fact that the difference between the high and low line was increased during the last generation of selection for both lines.

(b) Low line: Similarly the unweighted averages of the two sexes were obtained for the low line. A linear regression with the following equation was then fitted:—

$y = 19.9679 - 0.0508\ a$ (y = mean chaeta number, a = generation number).

The regression coefficient -0.0508 ± 0.0322 is not significant ($t_6 = -1.577$, $P5\% = 2.447$). The selection for low chaeta number, therefore, has not been effective.

2. *Phenotypic Variance.*

The results in Table V suggest that the "between bottle" variance in all generations of selection for high chaeta number and also the "within bottle" variance gradually decreased up to HS4. After that, the variances are more or less stable with only slight fluctuations.

Since the variance "between bottles" accounts for a larger portion of the total environmental variation, the effect of selection can therefore be observed from the changes in "within bottle" variance.

Selection has therefore increased the mean chaeta number (Table I) and decreased the variance (Table V) and when the mean values are not changing, the variances are unaffected by the selection.

3. *Heritabilities.*

Lush (1945) described several methods for the estimation of heritability. In the present study the heritability was estimated by the following methods:—

(a) In the first method heritability was measured by the following ratio:—

$$\text{Heritability} = \frac{\text{Progress reached}}{\text{Selection differential}}$$

Only the mean of the counting from one bottle from which the selection was made was used for obtaining the selection differential and the progress reached, the latter being calculated as the difference

between the generation from which the selection is made and the following generation.

The estimates were calculated over the two halves of the selection period (HSO to HS5 and HS6 to HS10) firstly, because selection has changed the mean chaeta number up to HS5 and secondly, it has the advantage of cancelling environmental fluctuations during the course of five generations. In order to compare the results of the two lines, the estimates in the low line were calculated for the period LS2 and LS8, which corresponds to HS6 to HS10 in the high line.

The results indicate that the heritability is very low during the period when response to selection has ceased.

TABLE VI.
Estimates of Heritabilities.

	Generation No.	Female	Male
High Line .	HSO to HS5	0.243	0.200
	HS6 to HS10	0.091	0.052
Low Line .	LS2 to LS8	0.007	0.052

(b) Considering HS4 as a population from which both high and low lines have been set up, the heritability for any subsequent generation can be estimated as the difference between the means of the two lines (i.e., progress reached) divided by the total amount of selection practised up to that generation. The estimates obtained by this method are presented in Table VII.

TABLE VII.
Estimates of Heritability.

Generation No.	Female	Male
HS5/LS1	0.24	0.06
HS6/LS2	0.37	0.15
HS7/LS3	0.09	0.09
HS8/LS4	0.08	0.07
HS9/LS5	0.06	0.04
HS10/LS6	0.08	0.05

The estimates obtained by the above method suggested low heritabilities in the second half of the selection period. In order to confirm this, it was decided to obtain further estimates from the regression of the off-springs on their mid-parents.

Ten families each consisting of a single pair of flies were set up from HS9. The selected pairs were mated in the order of their chaeta number—females with the highest chaeta number mated with males with the highest chaeta number—so that there was a high phenotypic correlation between chaeta number of the parents. This positive assortative mating has the advantage that it greatly increases the accuracy of the estimates of the regression of the off-spring on their midparents in comparison with those obtained by random mating, without introducing any statistical bias. The value of regression co-efficient thus obtained was—0.0477 ± 0.096 ($t_8 = 0.497$, P5% = 2.306), which is not significant.

B. A line of Breeding without Selection (N.S. Line.)

This line was set up from the 5th generation of selection for higher chaeta number. Ten female and ten male flies were taken at random from the second bottle of the HS5 without any reference being made to their chaeta number. These flies were mass mated for three days and cultured in three bottles, the breeding parents being transferred to a new bottle every day.

Results of Table VIII clearly indicate that means and variances are unchanged.

Discussion

In the high line selection has changed the mean chaeta number from generation to generation up to HS5 by increasing the frequency of the desirable genes (+ genes) and decreasing the frequency of the undesirable genes (— genes). As the selection for lower chaeta number was started from HS4, when the frequency of the minus genes was already reduced considerably, the low line did not return to the level of the unselected population. From HS6 and its corresponding

TABLE VIII.

Means and Variance in N.S. Line.

Generation No.	Mean Chaeta		Variance*	
	Female	Male	d.f.	M.S. (within bottle)
1	21.0 ± 0.14	19.3 ± 0.18	313	2.60
2	20.9 ± 0.24	19.4 ± 0.29	194	2.62
3	21.0 ± 0.19	19.3 ± 0.21	204	2.66
4	21.7 ± 0.16	19.6 ± 0.33	183	2.79
5	21.7 ± 0.16	19.6 ± 0.33	151	2.57
6	21.1 ± 0.17	18.9 ± 0.31	182	2.64

*Combined sexes.

LS2 (both inclusive) there was no significant advance in the mean chaeta number in either direction because:—

(1) Either the genes responsible for chaeta number have been fixed through selection and the stock is homozygous. Therefore further progress through selection is impossible, or

(2) the chromosomes carried these genes (or block of genes) which are linked together and also linked with other genes such as those affecting fertility.

It is improbable that an upper limit to selection for a polygenic character is reached by a gene fixation. If there are N pairs of desirable genes, a homozygous will be found only in q^2N animals where q is the frequency of each gene. Thus, for 8 pairs of genes, where the desirable alleles each have a frequency of 0.5, only one in 65,536 of the individuals will possess the extreme genotype toward which the selection is directed.

It is suggested that although the stock was still heterogeneous for chaeta number, due to the linkages of the genes, selection could not increase the chaeta number. It is possible that if the selection had been continued further, the potential variability as postulated by Mather (1949) may have been released. The evidence supporting the presence of potential variability in our stock was obtained from another experiment where a few flies with chaeta number 42, 38, 32 and 31 appeared. Since in the high line the maximum chaeta number was found to be only 27, such a high chaeta number could be due to recombination of the genes within the chromosome.

The heritability for chaeta number in the un-selected population as estimated in this experiment, is 38% in the female and 20% in the male. The estimates for the same stock obtained by parents offspring relation in the family experiment (to be published elsewhere) is 24% in the female and 16% in the male. The regression of the mean of the progeny on the mean chaeta number of their midparents in the 9th generation of selection is—0.0477 ± 0.096 which is not significant. The absence of response to selection is therefore associated with practically zero estimate of the heritability. The heritability in the low line is very low because this line was started from HS4 when the variability of the minus genes for chaeta number had already been reduced.

The N.S. line was started from HS5 and no selection was practised in this line at all. It loses approximately one chaeta when compared with the high line. If the high line were completely homozygous, a line of mass mating started from it would tend to decrease if the non-additive effects of the genes were important. It is therefore possible that in the high line the selection has maintained the suitable combinations and has therefore higher chaeta numbers whereas with the mass mating these combinations break down and the mean chaeta number falls. This point would have been proved if the

selection had been re-started from the N.S. line or otherwise the setting up of a few inbred lines may have helped to estimate the non-additive portion of the total genetic variance. However, this fact was not further investigated.

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TECHNICAL NOTES

A RESPONSE BY KIKUYU GRASS TO POTASH FERTILISER ON A RED BASALTIC SOIL OF THE TWEED RIVER DISTRICT OF NEW SOUTH WALES

Areas of red basaltic soil occur on the north-eastern border of New South Wales. They are related to the "Big Scrub" soils of the Richmond River district and were described by Parbery (1939a) who found many samples of these soils to be deficient in potassium in analytical studies (1939b).

A recent report by Crofts, Pulsford and Jenkins (1955) records significant responses by a clover stand consisting of Mount Barker subterranean clover (*Trifolium subterraneum* L.), crimson clover (*T. incarnatum* L.) and New Zealand certified broad leaf red clover (*T. pratense* L.) to potassium supplied as KCl B.P.

A recent field experiment on red basaltic soil at Bilambil (situated approximately 7 miles from Tweed Heads and 12 miles from Murwillumbah, N.S.W.), disclosed a marked response to commercial muriate of potash by Kikuyu grass (*Pennisetum clandestinum* Hochst.). It is believed that this is the first recorded instance of a response to potash by a grass (other than sugar cane) on these red soils or elsewhere in Australia.

The experiment plots were situated in a paddock whose history is incompletely known, but which certainly grew sugar cane in the early years following clearing. The present cover consists of unthrifty Kikuyu grass associated with small plants of White Clover (*T. repens* L.).

In October, 1954, the area was fertilised with commercial nitrate of soda at the rate of 1 cwt. per acre, with no apparent response. In December, 1954, topdressing with 1½ cwt. superphosphate and 3 ozs. molybdenised trioxide per acre brought about an obvious increase in the proportion of clover plants in the sward.

On March 30, 1955, single plots 11 yards square were treated with commercial muriate of potash at rates of nil and 300 lb. per acre in combination with commercial sulphate of ammonia at rates of nil, 150, 600 and 1,200 lb. per acre.

On May 23, 1955, responses to muriate of potash and sulphate of ammonia at the two higher rates of application were very evident and sample cuts were taken from the plots, the yields of green material being shown in Table I. The samples were air dried prior to despatch for chemical analysis. The ratio between wet and air dry weights of the various samples showed little variation.

The 600 and 1,200 lb. per acre rates of sulphate of ammonia application brought about an almost complete destruction of white clover plants. An accurate assessment of the effect of sulphate of ammonia at 150 lb. per acre and of muriate of potash on clover plants could not be made because of lack of replication, moreover the trial period was one of relative clover dormancy. Subsequent experience elsewhere on the same farm indicates that white clover treated with potasic fertilisers will show a significant yield increase in spring, 1955.

TABLE I.

Green weight yields of kikuyu grass plus white clover.

Treatment	Yields in lb per acre (wet, as harvested)		
	Muriate of potash		Total
	Nil	300 lb/ac.	
Sulphate of ammonia			
Nil*	5,250	10,000	15,250
150 lb/ac.†	5,500	12,000	17,500
600 lb/ac.†	12,000	22,000	34,000
1,200 lb/ac.†	21,000	18,000	39,000
Total	43,750	62,000	

*Mean of two plots.
†Single plots only.

TABLE II.

Green weight yields of white clover.

Treatment	Yields of white clover		
	Yields in lb per acre (wet, as harvested)		
	Muriate of potash		Total
	Nil	300 lb/ac.	
Sulphate of ammonia			
Nil	1,430	1,250	2,680
150 lb/ac.	910	970	1,880
Total	2,340	2,220	

Table II compares the yields of white clover from plots receiving nil and 150 lb. sulphate of ammonia per acre. It is apparent that the greater yield from plots receiving such treatments plus muriate of potash results mainly from extra grass growth.

Although the pasture is clover dominant during the spring months, plants are never robust, and subsequent grass growth shows every evidence of severe nitrogen deficiency. Apparently potassium will confer a twofold benefit in increasing the amount of nitrogen fixed by the legume and the efficiency of its utilization by the associated grass.

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E. J. WARING.

Department of Agriculture,
Murwillumbah, N.S.W.

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THE EFFECT OF PROTECTION FROM GRAZING ON THE BOTANICAL COMPOSITION OF AN ANNUAL-TYPE SUBTERRANEAN CLOVER PASTURE

Although it is recognised that annual-type pastures growing in a Mediterranean climate fluctuate widely in botanical composition from year to year, the causes of such changes have not been adequately investigated. The problem is of some practical significance, especially in connection with nutritive value to the grazing animal during the dry season. A number of factors which influence botanical composition in clover pastures are being examined by the writers. One of these, viz., grazing pressure, will be considered here.

Botanical composition changes were followed over a 7-year period, from 1948 to 1954, on an area of Crawley sand at Nedlands, Perth, which was sown to Dwalganup subterranean clover in 1940. No precise records were taken prior to 1948, but field notes show that the proportion of volunteer annual grasses was always very low, the pasture being essentially clover dominant with some capeweed (*Cryptostemma calendula* (L.) Druce). During this period the pasture was heavily stocked with Merino wether sheep (4 to 5 sheep per acre per annum) on a continuous grazing schedule.

In the autumn of 1948 an exclosure measuring 80 links x 30 links was erected on the pasture and at the same time an adjacent area comparable in size and botanical composition was defined under open grazing, where the previous rate of stocking was maintained. The two observation plots received superphosphate and potash fertilizer annually. To avoid the complications arising from excess litter on the enclosure, the dry material was mown and removed each year, after seed shedding in all species was completed.

Estimates of botanical composition (weight basis), made at the conclusion of each growing season, are shown in Figure 1. While the grazed area consisted throughout of clover and capeweed, in varying proportions, the ungrazed area ran quickly to volunteer annual grasses and Erodium (*Erodium botrys* (Cav.) Bertol). Both capeweed and clover persisted in the exclosure, the proportion of the legume being very low (approximately 5 per cent.) after two years' protection.

Two points merit some consideration. In the first place, the appearance of Erodium as a significant component in the exclosure was unexpected. This species is widespread in clover pastures on light-textured soils in the South-West of Western Australia, but is rarely observed on Crawley sand at Perth, except on ungrazed volunteer pastures which do not receive superphosphate. The reason for its absence from the grazed clover pasture in the present instance is obscure, especially in view of the frequent number of seasons where a period of moisture stress follows the opening rains —a condition generally considered favourable to Erodium dominance. In any case, the implication that the tolerance of *Erodium botrys* to heavy grazing pressure is low relative to that of subterranean clover and capeweed needs further investigation.

Secondly, there is the invasion of annual grasses on the exclosure. Several observations elsewhere in the South-West suggest an inverse relationship between stocking rate and proportion of annual grasses in subterranean clover pastures. This is supported by the present

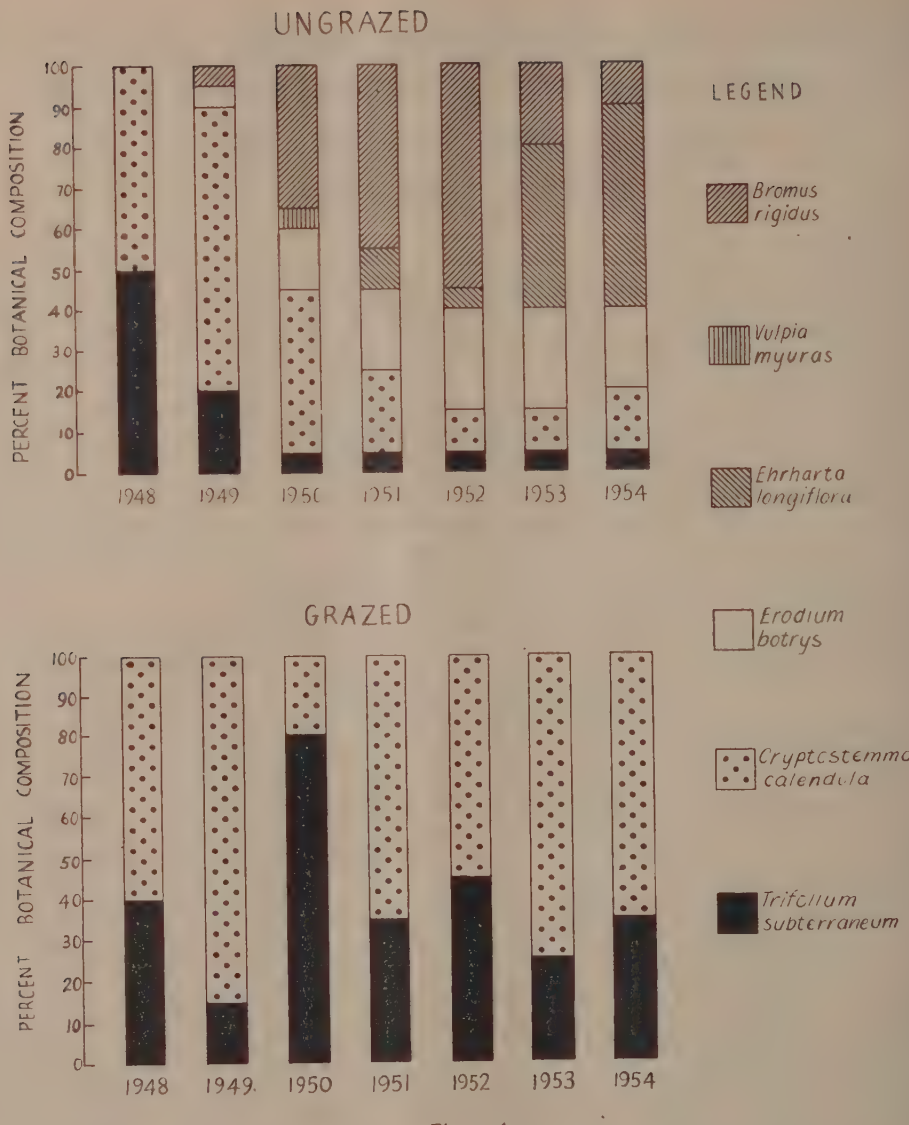

Figure 1.

Showing the changes in botanical composition of grazed and ungrazed pastures.

work, taken in conjunction with other data from a grazing experiment at Nedlands, where a stocking rate of less than 3 sheep per acre per annum, i.e., moderate to heavy grazing, has maintained the annual grass component of the pasture at about 20 to 30 per cent. over several years.

Ripgut brome grass (*Bromus rigidus* Roth.) is frequently observed amongst the volunteer annual grass complement of clover pastures, at Nedlands and more generally in the South-West, so that its early appearance in the exclosure was anticipated. The eventual displacement of this species by annual veld grass

(*Ehrharta longiflora* Sm.), on the other hand, was not anticipated. A relatively recent accidental introduction from South Africa, annual veld grass is widespread in the surrounds of Perth, including Nedlands. Moreover, it appears from time to time, and for short periods, when clover pastures at Nedlands are left ungrazed for one or two years, but disappears rapidly on resumption of stocking. The two grasses have not been observed closely in the past growing in association. Possible explanations for the ultimate dominance of the veld grass over the brome grass in the absence of grazing are (i) higher growth rate during early winter, and/or (ii) heavier seed production.

In conclusion, the results provide an illustration of the way in which differential grazing pressure may profoundly modify botanical composition of subterranean clover pastures. And more specifically, there is some indication that of the species common to clover pastures, both capeweed and subterranean clover can withstand heavier grazing pressure than either ripgut brome grass or Erodium.

R. C. ROSSITER.
R. J. PACK.
Division of Plant Industry,
C.S.I.R.O., Nedlands,
Western Australia.

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AN APHID TRANSMITTED VIRUS AFFECTING SUBTERRANEAN CLOVER

At a Plant Diseases Conference held at Hawkesbury Agricultural College, Richmond, N.S.W., in June, 1955, attention was drawn to a serious disease affecting subterranean clover in South Eastern Australia. Delegates to the Conference reported that it was widespread in N.S.W. and that an apparently similar condition occurred in Tasmania, Victoria and Queensland. The symptoms varied slightly even within one district, but stunting, with leaflets marked by marginal chlorosis and puckering, were characteristic. Symptoms similar to these were reported by Valder (1954) who stated that the disease had been transmitted experimentally but it was not known whether one or more viruses were present. The general appearance of affected plants suggested mineral deficiency as illustrated by Millikan (1953) but there was no recovery following fertilizer treatments. Symptoms were not those of bean yellow mosaic virus disease, but were similar to those resulting from infection by some leafhopper-transmitted viruses.

The occurrence of the disease in autumn and early winter suggested either seed transmission, or that an efficient insect vector was present soon after germination. Some information on virus transmission under glasshouse conditions has now been obtained and the results indicate the presence of an aphid-transmitted virus.

The results of preliminary experiments are as follows:—

(1) Seed transmission. Samples of seed from the 1954/55 harvest were obtained from areas in N.S.W. where the disease was widespread in the current season. Approximately 3,000 single plants of the strains Mt. Barker and Dwalganup were grown in the glasshouse for a period of several weeks. No disease symptoms were seen on any of

these plants and it is unlikely that seed transmission occurs.

(2) Mechanical transmission. Forty sub-clover seedlings (strain Wenigup) and from 12 to 15 each of Mt. Barker, Clare, Bacchus Marsh, Dwalganup and Red Leaf were mechanically inoculated using carborundum with sap expressed from infected Mt. Barker plants. No transmission occurred.

(3) Tests with leafhoppers. Three species of leafhopper were tested as possible vectors. *Austroagallia torrida Evans and Orosius argentatus* (Evans) from virus-free colonies were fed for seven days on infected clover plants and then for seven days on healthy Mt. Barker plants. They did not transmit any virus disease. *A. torrida* infected with the rugose leaf curl virus (Grylls, 1954) transmitted that disease but no symptoms similar to the subterranean clover disease were produced. Symptoms of the legume "little leaf" disease (Hutton and Grylls, 1956) on Mt. Barker seedlings were similar during early development to the clover disease but the similarity was lost after a short time.

Eurinoscopus punctatus (Evans) was tested but failed to transmit the disease, although it produced marginal yellowing and cupping of leaflets on seedlings apparently caused by direct feeding damage or the injection of a toxin. These symptoms were for a short time very similar to those of the early stages of the subterranean clover disease.

(4) Aphid transmission. Symptoms identical with those seen in the field were obtained when *Aphis craccivora* Koch. was used as a vector. Apterous aphids, from a colony established on an infected Mt. Barker subterranean clover plant, were starved for approximately 4 hours. They were then placed in pairs per plant on 60 Mt. Barker seedlings and fed for a period of one hour. After 12 to 21 days 20% of the plants developed symptoms of the subterranean clover disease, while all control plants remained healthy. Transmission was also obtained with *Myzus persicae* Sulz., though less efficiently, and it is highly probable that other aphid species act as vectors.

The results of these preliminary investigations demonstrate that the disease is due at least in part to an aphid-transmitted virus. Further work is in progress.

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N. E. GRYLLS.

Division of Entomology,
C.S.I.R.O.,
Canberra, A.C.T.

F. C. BUTLER.

Agricultural Research Institute,
Wagga Wagga, N.S.W.

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NEWS ITEMS

Water Use Research.

The Water Research Foundation of Australia has granted two fellowships for investigations into the agricultural use of water. The Foundation was formed in November, 1955, following a successful symposium on "Australia's Water Resources" held at the N.S.W. University of Technology and already is being well supported.

The fellowships, each worth £1,500 are for research into development of water harvesting on the farm and the efficacy of land treatment on water conservation and flood mitigation. One fellowship will be tenable at the University of Sydney and the other at the N.S.W. University of Technology. They are for an initial period of 12 months and may be renewed if progress is satisfactory and finance is available.

Dairy Research Laboratory.

Space for a new dairy research laboratory has been allotted by the Queensland Butter Marketing Board in its building which was recently opened at Hamilton, Brisbane. Officers of the Department of Agriculture and stock would be solely engaged in examining the quality problem of the butter industry and in providing technical advice to butter factories. Regional dairy research laboratories in Queensland are already operating at Toowoomba, Murgon and Malanda.

Poultry Research Lecture Tour.

Mr. F. Skaller, Officer-in-Charge of the C.S.I.R.O. Poultry Research Centre, Werribee, was recently in New Zealand as guest of the New Zealand Poultry Board and gave a number of lectures on *Improving Egg Production through Breeding* at the Poultryfarmers' Refresher Course held at Massey Agricultural College from February 7-9th. The New Zealand Poultry Board also arranged for a number of addresses to be given by Mr. Skaller at other important poultry districts of New Zealand after the course at Massey.

During his stay in New Zealand, Mr. Skaller was able to attend the 16th Annual Meeting of the New Zealand Society of Animal Production at Massey from February 1-3rd and to represent there the Australian Society of Animal Production, of which he is a member of Federal Council.

Tobacco production programme.

Proposals that are likely to have far-reaching effects on the rapidly-expanding tobacco industry were considered at a Canberra meeting of the Central Tobacco Advisory Committee on 6th December, 1955. The committee includes grower and government representatives of the four tobacco-growing States (Queensland, New South Wales, Victoria and Western Australia) and representatives of the Commonwealth Department of Commerce and Agriculture, the C.S.I.R.O. and the manufacturers.

Commonwealth Bank Grant.

The Commonwealth Bank of Australia has approved monetary grants totalling £65,647, from the Rural Credits Development Fund to various bodies throughout Australia for investigational work in connection with the promotion of primary production. The University of Queensland received £7,887 for research into various aspects of soil fertility, mottled wheat, poultry genetics and the cattle tick.

Cattle Tick.

An intensive campaign aimed at eradicating cattle tick from north-eastern New South Wales has just been started by the Department of Agriculture. Employing over 700 men it is estimated to cost £3 million. All musterable stock in the area will be dipped every 14 days in a DDT suspension for a period of 15 months. All unmusterable stock will be shot. Mr. C. C. Blumer, Chief of the Division of Animal Industry, who is directing the campaign points out that the basis of the programme is that the cattle tick must spend at least 16 days attached to an animal to enable its full development.

New School of Dairy Technology.

A new dairy factory and school of dairy technology was recently opened at Hawkesbury Agricultural College, Richmond, N.S.W., by the Minister for Agriculture and Food Production, Mr. E. H. Graham. The factory is one of the best equipped in the world and has the latest plant for the treatment and bottling of fresh milk and the manufacture of a wide range of dairy products. The school will provide training of a high standard to students of the College in dairy produce manufacture which is an important part of the diploma course in dairying.

The Principal of the College, Mr. H. R. Richardson, explained that the object of the School of Dairy Technology was to provide a sound theoretical and practical training (of high standard) for the industry and to carry out research into problems of the manufacture of milk products.

David Syme Research Prize.

Dr. H. G. Andrewartha, Zoology Department, University of Adelaide and Dr. L. C. Birch, University of Melbourne, have been jointly awarded the David Syme Research prize for 1955 at the University of Melbourne for their book "The Distribution and Abundance of Animals" which was published in 1954.

D.D.T. Resistant Codlin Moth.

The promise shown by Malathion against D.D.T. resistant codlin moth in 1954-55 trials carried out by the South Australian Department of Agriculture at Paracombe, is being substantiated in further trial work and grower experience this season. Parathion and diazinon have also given good control.

The School of Agriculture at the University of Sydney.

The University of Sydney has just issued a report* which reviews the establishment and development of the Sydney School of Agriculture and provides a brief, though comprehensive statement of the work of its several Sections for the period 1951-1954. The Report is a most valuable document in that, for the first time, the wide scope of the teaching and research activities of the School are described. This sort of authoritative publicity will be of great value to the Sydney School of Agriculture and to the profession of agricultural science as a whole.

Copies are available gratis on application to the Editor:

Dr. J. M. Vincent,
School of Agriculture,
University of Sydney,
Sydney, N.S.W.

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* *University of Sydney, School of Agriculture, Report No.* 1, *December* 1955, *pp.* 79.

Wheat Improved by Ley Farming.

The results of the 1955 R.A.S. Field Wheat Contests in the Riverina area of New South Wales have markedly demonstrated the value of crop rotation incorporating a period under grazed pasture, either sown or volunteer, in the growing of wheat. Some form of ley farming is now widely practised by wheatgrowers in the Riverina. Mr. J. A. O'Reilly, the area's senior district agronomist considers that this development can greatly increase wheat production in the area particularly by rejuvenating "tired" wheat soils.

The winning crops all yielded between 45 and 50 bushels per acre and were all grown on land which had been out to ley. The introduction of pastures and stock into the wheatgrowing rotation will be an important factor in not only increasing yields but also making possible long-term stability on wheat farms by maintaining soil fertility.

Sherpa Wheat.

Sherpa wheat has risen rapidly in popularity since its release by the Victorian Department of Agriculture in 1954. In its second year it was sown on over 70,000 acres, mostly in the Mallee and North-eastern districts and it is already the fourth most popular variety in the State. Now that adequate seed supplies of Sherpa are available it is recommended by cereal officers of the Department that this variety should completely replace Quadrat in the above mentioned districts. This change should result in an improvement in both the yield and quality of wheat grown in these areas.

Last year many satisfactory reports were received concerning the performance of Sherpa, the most noteworthy being the winning of the 1955 Northern Districts Wheat Crop Championship. This crop, which represented the Wangaratta district, was grown on clover ley land and yielded 41.2 bushels per acre over the competition 50 acres. Generally seasonal conditions throughout the Northern Districts were not favourable to the production of high yields during 1955 and the effects of the wet winter and later the influence of rust, took their toll of the wheat crops.

Sherpa wheat was selected at Dookie Agricultural College from a cross between Ghurka and a Pye wheat named Amity. It is of early-mid-season maturity. The straw is purple in colour while the head is white. Sherpa is resistant to flag smut, but is susceptible to rust. It produces flour of better quality than that obtained from the main Victorian varieties.

Serrated Tussock—a threat to Pastures.

Serrated tussock (Nassella trichomata) is looked upon, with good reason, as potentially the most dangerous pasture weed in New South Wales. It is an accidental import from South America and was first reported from the Yass district in 1935. Today, on the central and southern tablelands 20,000 acres are heavily infested and 1½ million acres lightly infested and the grass is spreading.

Serrated tussock is a perennial five-leaved grass forming a dense growth. It has no feed value and is avoided by sheep and cattle and even rabbits and therefore causes a rapid loss of carrying capacity. Being a weed of the cooler and wetter areas and very drought resistant it is a serious threat to the State's main pasture improvement regions. The best control is by sound pasture improvement methods, on country which can be cultivated the preliminary cultivations will kill out most of it. Where cultivation is impracticable spraying with TCA at 75 lbs/acre is recommended.

New Oat Variety.

Seed of a new variety of oat named Alpha was made available by the Victorian Department of Agriculture in January. The new variety was developed at the Mallee Research Station, Walpeup, where it was selected by Mr. H. J. Sims, Department Cerealist.

The new oat is capable of producing a great bulk of early feed for grazing, and in this respect is superior to any other variety in Victoria. It will also provide a satisfactory total amount of grazing throughout the year.

The grain is relatively small and yields are rather lower than those of commonly grown varieties. For this reason the variety is not recommended for hay or grain production.

Australian Society of Soil Science.

The inaugural meeting of the *Australian Society of Soil Science* was held in Melbourne last August. It was decided to form a federal organisation based on State branches similar to that of the Australian Institute of Agricultural Science and the Royal Australian Chemical Institute. A committee, consisting of *Professor L. J. H. Teakle, Messrs. G. D. Hubble and P. J. Skerman* was appointed to draft the constitution.

During last November the inaugural meeting of the Queensland Branch of the A.S.S.S. was held in Brisbane. Professor Teakle was elected Convenor-Chairman and *Mr. S. A. Waring*, Secretary-Treasurer. Eighteen interested persons attended this meeting.

Pharmaceutical Products from Wool Grease?

The possibility of obtaining important pharmaceutical products such as cortisone from wool grease by the use of bacterial processes has been outlined by Dr. P. Woodford of the Department of Textile Industries at Leeds University, England. His suggestions concerning the line of research to be followed were contained in an essay entitled "Living Reagents" for which he was awarded the Gold Medal and prize offered by the British scientific journal "Research".

It is suggested that micro-organisms might well carry out the molecular transformation required to convert cholesterol, of which wool grease contains considerable quantities, into pharmaceutical products. At the present time chemical methods are used, but the reaction is a fairly drastic one.

It is also possible that micro-organisms could be used to transform lanosterol into similar products, thus utilising an otherwise commercially useless substance.

Dr. Woodford suggests that suitable bacteria might be obtained from fermented press cake which is a product of the wool grease industry, or alternatively some of the strains present in sewerage filters used to purify effluents containing wool grease might prove effective.

Improved Pasture in New South Wales.

The area of improved pasture in New South Wales has increased rapidly in the last five years from 3.7 million acres in 1950-51 to 6.9 million acres in 1954-55. Official statistics also show that, in 1954-55, 3.5 million cwt. of superphosphate and 0.3 million cwt. of other artificial fertilizers were applied to 3.36 million acres of pastures. Thus it appears that about half the acreage sown to grasses and clovers was not top-dressed. Much of the improved pasture is not good largely due to the fact that land holders have not worked out the most efficient system of pasture management for their conditions. For example, rye-clover pastures are not tolerant of intense light and, apart from drought, the commonest cause of failure is overexposure of the crowns of the plants as a result of over-grazing.

Record Oat Harvest in New South Wales

A record oat crop of about 18 million bushels of grain and 140,000 tons of hay has been harvested in New South Wales this season despite a comparatively low grain yield, due to rain damage, of 18 bushels to the acre. The previous highest grain harvest was 13½ million bushels averaging 22½ bushels per acre in 1947-48. This year much of the grain is of inferior quality because of rust and army worm damage. Farmers and graziers are being urged by the Department of Agriculture to store oat grain on the farm as it is a most valuable drought feed, especially for sheep, and is available at comparatively low cost.

Pasture Development Praised.

Praise for Australia's pasture development work has come from Dr. A. B. D. Cassie, head of the Wool Industries' Research Association at Leeds, who toured Australia as a delegate to the International Wool Textile Conference.

Dr. Cassie has stated that pasture improvement through scientific use of fertilisers could ultimately overshadow the achievements of myxomatosis. He considers that the main contribution has been the discovery of the widespread importance of trace elements enabling poor scrub land to be developed under pasture.

The use of superphosphate to increase growth, in conjunction with the use of new strains of pasture plants has made possible great increases in carrying capacity.

Dr. Cassie also praised Australian research on wool improvement, which he considers is being pursued with great vigour.

War Against Grasshoppers.

An intensive campaign to control grasshoppers in North-Western Victoria was carried out by the Victorian Department of Agriculture during November and December last.

Swarms were particularly dense during the middle of December during which period more than 100,000 acres were sprayed from the air with benzene hexachloride. In all some 220,000 acres were sprayed during the five week campaign.

Ground spraying has since been used to clean up small localised patches and to control summer hatching in irrigation areas.

The total cost of aerial spraying and local campaigns during the season was in the vicinity of £185,000. It was estimated that at least £16 million worth of crops and pastures were saved from partial or complete destruction.

Some damage, however, did occur, more particularly to oat crops, and to irrigated pastures and lucerne in Northern Victoria.

Overseas trip by Dr. Callaghan.

A Carnegie Corporation Travel Grant has been awarded to Dr. A. R. Callaghan, Director, Department of Agriculture of South Australia, who will leave during April for a four month trip through the United States and Canada. Dr. Callaghan will study Agricultural extension methods with special reference to the administrative aspects of the work in both countries, although by far the greater part of his time will be spent in the U.S.A.

The second objective of his visit will be to examine the wheat marketing systems, especially classification and grading used in the wheat growing regions of Canada and the U.S.A. through which he will travel.

Crossbred Poultry Outyield Purebreds.

"Criss-cross" breeding, a system of continuous crossing, has given excellent results in breeding experiments at the C.S.I.R.O. Poultry Research Centre, Werribee, Victoria. This system has produced birds superior to the purebred parent stock from which they were derived and at least equal in egg production to single cross birds.

Throughout a period of six years, criss-crossed White Leghorn and Australorp pullets outyielded an improved line of purebred White Leghorns—the highest producing of the two parent breeds. The criss-crossed birds averaged about two dozen

more eggs each year. Chick mortality is also lower among the hybrids. Another advantage is that the entire flock may consist of crossbred layers with the exception of the required purebred sires which can be purchased from outside.

In this method of breeding, single cross dams are mated back to a sire of one parent breed in the first generation. In the next generation the back-crossed female progeny are mated to a sire of the other parent breed. The procedure is carried forward indefinitely, sires of the two breeds being used alternately in successive generations.

However, the Werribee experiments confirm the need for quality in the purebred parent stock. The more highly improved the parental stock the better will be the criss-cross progeny produce.

These experiments being carried out by the C.S.I.R.O. are not poultry breeding experiments as such but form part of an investigation on animal breeding systems in general. Poultry are used as the test animals because they have certain advantages such as their ability to produce numerous offspring, the quick turn-over of generations, and the relatively low capital and running costs concerned in poultry husbandry.

This work of comparing different breeding systems which was begun at Werribee in 1947 has given the first scientific demonstration in Australia of the advantages of hybridization in animals.

Going on a Study-Tour? Some Pointers.

D. V. WALTERS of the C.S.I.R.O. Research Station at Merbein, Victoria has compiled the following list of pointers which will be useful to prospective study tourists.

This list is born out of the writer's experiences both as a host to many student-tourists and as one himself. It is a compilation of the ideas of many people—ideas which have been tried and found successful.

1. Be clear in your mind what your purpose is. What do you want to learn? Whom do you want to talk with? What do you want to see? Why?
2. Two heads are better than one. Try to join up with someone else with similar interests.
3. Arrange for flexibility in your itinerary—allow one working day in each week unalloted. Especially allow the last few days of your visit unallotted so you can make some last-minute checkbacks.
4. Stay a longer time in fewer places rather than cram in many stops with a short time in each.
5. Travel light—two sets of nylon shirts and underclothes are sufficient, but buy the type of nylon that "breathes." As literature collects, post it home.
6. A preliminary statement is essential to success of a study-hour. It lists the visitor's objectives, subject matter, age, training, experience and qualifications and should be as full as possible, including his social, recreational and other interests. This statement should be duplicated and sent ahead to each centre to be visited.
7. On arrival at a centre, add to the preliminary statement by telling about your interests. Use visual aids if possible—a map of your region, photographs, colour transparencies, literature. But don't talk about yourself too much—say "Ask me questions." The more your host knows about your interests, the more efficient treatment he can give you.
8. If asked to address a gathering, keep it brief—20-30 minutes. Ask for questions. Speak slowly, so your accent will be understood.
9. Supplement written notes with photographs. Use a fast film for dull lighting occasions. Have a colour camera in addition, if you can.
10. Ask the meaning of words. Ask to be shown the object under discussion. Even in different parts of the English-speaking world, words have different meanings. Get scientific names of plants, animals, insects.
11. Start writing your report as you go. Use small sheets of paper and put only one idea on each sheet. Sort the sheets into subjects and your report starts to take shape.
12. Check-back before leaving. Show your host your notes—or a skeleton outline of your report for that visit—and ask: "Is it true? What have I missed? Is it properly balanced?" This is probably the most valuable tip any student-tourist can get.

The above pointers are meant for those going on study-tours but a knowledge of them can make you a better host to a visiting Fellow. In addition, give him statements about your district, its environment and production, research and extension facilities, etc. It will help him too, if you explain about our hotel and office hours, holiday dates, and provide him with road maps, postcards and other human-interest mementos of his visit.

Building Additions at the Institute of Agriculture, Western Australia.

The additions to the main building of the Institute of Agriculture, University of W.A., have now been completed and are in use. The additions increase the accommodation at the Institute by a third, and consist of 3 laboratories, library, staff room and hot and cold rooms.

SEE ALSO PAGES 36 AND 39 FOR FURTHER NEWS ITEMS.

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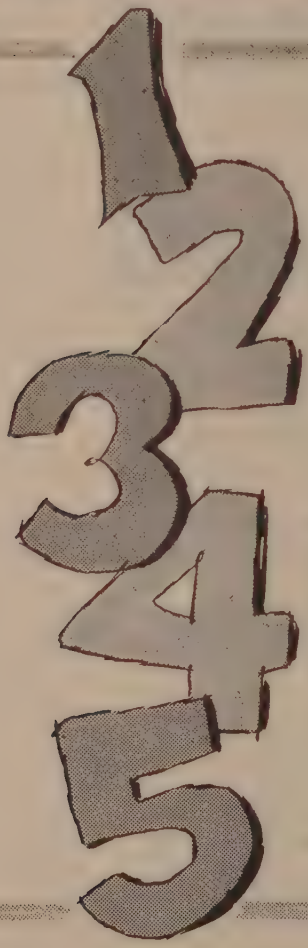

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TALKS

"The Effectiveness of Three Cultural Methods in Seeding Spear Grass Pastures."

J. K. Leslie, Student Finalist—Queensland Branch Prize.

The address by Mr. Leslie summarised the effects of three cultural treatments, namely, burning, rotary hoeing and tyning on a stand of bunch spear grass (*Heteropogon contortus* (*L*) *Beauv.*) and the ability of two grasses, green panic (*Panicum maximum* var. *trichoglume* (K. Schum) Eyles.) and scrobic (*Paspalum scrobiculatum* L.) to establish themselves when sown separately after the above treatments.

Both grasses which were planted at the end of February germinated equally well. By the end of July there was still no appreciable variation in stand, but there was a considerable difference between the amounts of spear grass present in each treatment. Both burning and tyning had an appreciable effect on the stand of spear grass at the end of the five month period, but were not as effective as rotary hoeing.

"A Study of Seed Germination in a Soil from Western Queensland."

R. W. Downes, Student Finalist—Queensland Branch Prize.

The germination of sorghum seed (var. Saccaline) in a soil from Blackall was found to be affected by soil moisture content, depth of planting and seed treatments which included soaking in water and tomato juice as well as pelleting with bentonite. Seed did not germinate when the soil moisture was less than 16% which was the equivalent of 60 points of rain penetrating to a soil depth of 3 inches.

At no soil moisture level did pelleting prevent seed germination. A lag in germination of 3.5 days resulted when pelleted seed was planted in soil containing 16-18% moisture. Pellets of bentonite containing tomato juice were slightly slower in germinating than were pellets of bentonite and water.

Mr. Downes summarised his studies by saying that there does not appear to be a future for pelleted seed in this field.

"Studies of the Growth and Sporulation of Cerebella andropogonis Ces."

A. J. Cowan, Student Finalist—Queensland Branch Prize.

Mr. Cowan studied certain factors which affected the growth and sporulation of *Cerebella andropogonis* Ces., a saprophyte in the ergot honey dew. He found that glucose and nitrate in synthetic media were the best sources of carbon and nitrate. The optimum temperature for fungal growth and for sporulation were 24°C. and 22°C. respectively. For rapid and abundant sporulation, it was recommended that *C. andropogonis* be grown at 22°C. on a synthetic medium containing 0.5% glucose.

"The Value of Extension Work in Increasing the Efficiency of Agricultural Production."

C. W. Strutt, Asst. Secretary, Division of Agricultural Production, Dept. of Commerce and Agriculture.

Mr. Strutt said that he believed agricultural extension work is of vital importance today. In Australia the emphasis is on reduced costs of production in order to compete on world markets. In the U.K. reduced costs would lower the burden of subsidies paid to primary producers out of general revenue. In underdeveloped countries increased production is necessary to raise levels of nutrition for increasing populations.

Estimation of the value of an extension service in increasing the efficiency of production involved three questions.

1. *What is the cash value of the increase in production that can be attributed to the fact that an agricultural extension service does exist?*

Experience amongst farmers shows how widely results can and do vary from farm to farm. The chief variables are:—

a. *The farmer himself*, his state of health, ability, knowledge and drive. His wife and children also have a significant influence on his state of mind and therefore ability to cope.

b. *The farm itself*. Natural fertility of soil. climate, size of farm, water supply and situation in relation to markets.

c. *System of farming adopted*, e.g., its suitability for the farm in question and to the cost/price ratio of the products from the farm.

d. *Capital invested and available for development*. Some farms carry too great an overhead due to overcapitalisation (e.g., bought at too high a price) while others may not have sufficient finance for full development.

e. *Labour*—both the actual labour force and the labour available for expansion of production.

Thus no two farms are alike, no two farmers are alike and no two consecutive seasons are alike. This situation makes it difficult to answer the question accurately. However, many cases are known in which spectacular improvements in farm incomes have been made as a result of advice given by extension services and government help in both the U.K. and Australia.

In the case of the U.K. the volume of agricutural production was increased from 140% to 150% of pre-war production in 5 years. Allowing only 10% of this as due to the extension service (N.A.A.S.) this represents a return of £20 million per year at a cost of less than £2 million per year.

A carefully planned investigation should be able to find an answer to this question. The in-

formation should be of immense value, e.g., in appropriation of public moneys for extension work.

2. *To what extent would the cash value of agricultural production be increased by strengthening the existing extension service?*

Here again we can only guess at the figure. Results would depend on the quality of the extension staff. Essential qualities of a good extension man are:—

a. Character—by nature of varied material he works with he must be a good mixer.
b. Enthusiasm.
c. Knowledge—must have sound wide experience to be able to gain confidence of farmers.

Administration of extension service is important in backing up field men. Poor administration and lack of understanding by central office of problems involved in field work affect morale of field men and lower their efficiency and farmers' respect for the service.

The answer to Question 2 is, *substantially*, always provided you can find the right men.

3. *Assuming the increase in production is profitable to the farmer, what is its value to him and to the rest of the community?*

It is vital for the increase in production to be profitable. The effect is like that of a stone thrown into a pond. If a farmer has money he will spend it. It is spent on property and stock improvement, improvements to home and to living and educational standards of the whole family and indirectly to the benefit of the whole community.

Conclusion.

Today with so many rapid advances being made by research workers a first class Agricultural Extension Service is essential to get that information over to the farmer.

An investigation into the value of an agricultural extension service properly carried out over a wide area of country would be extremely useful.

We cannot put a figure in terms of £ s. d. on the value of such a service, but I believe that in very few other ways, can a Government invest funds to better advantage.

"Present Day Plant Quarantine in New Zealand."

G. A. Helson, Research Superintendent and Officer-in-Charge of Plant Quarantine, Department of Agriculture, New Zealand.

Mr. Helson defined plant quarantine as the legal restriction of movement of commodities and goods to prevent introduction of diseases and pests into places where they are not present.

Since 1884 New Zealand had been interested in quarantine, and the Codlin Moth Act in that year was an attempt to keep the moth out of New Zealand but as there was no organized department to implement the Act the moth got in. In 1892 the Stock and Lands Departments were amalgamated to form the Department of Agriculture. That New Zealand today is free of many stock pests is due mainly to the wise policy at that time. At that time all fruit was being imported and with it many diseases were coming in. Finally in 1908 the Orchard and Garden Disease Act was brought down and in 1915 the Act and regulations were consolidated and from that time New Zealand had instituted its quarantine measures.

In 1949 the 7th Meeting of the Pan-Pacific Science Congress was held in New Zealand and a Symposium on Quarantine showed that New Zealand was vitally exposed to a great number of pests and diseases, and that the existing regulations were inadequate.

The present day plant quarantine service in New Zealand was developed following a three months inspection by Mr. Helson of the reorganized Australian service.

The Act was amended in 1950 to give the necessary power to bring down regulations to carry out legal aspects. Three categories of diseases and pests were recognized:

(1) those which would be catastrophic if introduced;
(2) those where the commodity can be sterilized or fumigated to get rid of the organism;
(3) those where the disease presents little or no hazard.

Mr. Helson pointed out the necessity of assessing the relative dangers to the country of the particular commodity with a knowledge of the pests and diseases which are likely to come in. He quoted as an example the Oriental fruit fly from oranges from Honolulu. This is one of the worst fruit flies in the world and stringent measures had to be taken to keep out the fruit fly from New Zealand. All aircraft are fumigated and passenger baggage is inspected at the point of origin, i.e., Hawaii, and a certificate is given to the pilot of the aircraft and a sticker placed on the baggage. This example of pre-flight inspection is the only one in existence at present and it facilitates passenger disembarkation by stopping the pest at the point of origin.

In order to enforce quarantine all aircraft and shipping must be met. Officers have to be trained in techniques of plant quarantine and well-versed in the legal requirements of other countries. At present there are 20 trained men and more being treated. The decreased time of travel nowadays greatly exceeds the life cycles of many pests. Hence the importance of an efficient plant quarantine service.

In addition to the 20 men in the field there is a headquarters staff consisting of 2 entomologists, 1 plant pathologist and 1 botanist. One of the entomologists is concerned with pests in New Zealand in seeds for export.

There are 5 major points of entry in New Zealand: Auckland, Wellington, Lyttleton (Christchurch), Dunedin and Bluff. At Wellington a Plant Quarantine Station was opened in 1954 and at Auckland and Christchurch a start was made in the building of modern fumigation plants. Small vacuum units of 10 cu. ft. were provided and handled all parcels coming into the country by post and air. Large vacuum units were provided first in Wellington to handle large quantities of goods.

All fumigation is by means of methyl-bromide, the change from cyanide having been made some years ago.

Mr. Helson informed the meeting that it was fruit fly investigations which had brought him to Australia on his present trip. An outbreak of the Queensland fruit fly had occurred in the Murrumbidgee Irrigation and mid-Murray areas from which New Zealand draws her oranges at certain times of the year. Grave consequences had arisen because New Zealand had stopped her imports of these oranges when the fruit fly broke out. On the Australian side it upset trade arrangements. The Commonwealth had put up some money for enquiry into the treatment of oranges.

"Development on Kangaroo Island, South Australia."

Mr. R. Hill, Dr. C. S. Piper and Mr. E. D. Carter.

Mr. Hill who had been closely associated with all stages of the development of the peneplain country of Kangaroo Island, outlined the circumstances which led to the establishment of a trial in 1939 when 560 acres of scrub was cleared at Parndana and pasture established.

Trial work by Mr. Strong showed copper was limiting and by 1944 carrying capacity was increased to 1.7 sheep per acre. In 1948 the area was accepted for War Service Land Settlement. To date, 100,000 acres have been logged, 87,000 acres seeded and 104 houses built. Sheep numbers have risen from 27,000 in 1936 to 203,000 in 1955. It is planned to clear 160,000 acres.

Dr. Piper outlined trial work on an important aspect of Kangaroo Island soils, viz., phosphate availability. He described the chemical properties of Seddon gravelly sandy loam and pot culture trials carried out at the Waite Institute by Messrs. Tyson and Lewis. These had shown a low phosphate recovery by clover plants. It was considered that the sesquioxides of the Seddon soils accounted for their greater fixative capacity. Compared to Urrbrae Loam, the Seddon soils require three times the amount of superphosphate for comparable growth of clover and this might mean that maximum production would not be attained in the field until a total of 30 to 60 cwt. of super. had been applied.

Mr. Carter described work at the Parndana Research Centre of the Department of Agriculture. Experimental work on pasture establishment had shown that production in the first year was influenced more by fertiliser application than seeding rate or seed bed preparation. Good pasture cover with associated grazing is the only practical way of combating scrub regrowth. Many trials had been carried out to compare clover and grass species in establishment of pastures.

He also described work on pasture renovation whereby predominantly annual and unstable pastures were converted to permanent pastures. This involved eliminating as much regrowth as possible, and ploughing to level the ground surface to a mowable state. It had been found that resowing to perenial grass was best if left after one year cereal crop followed by one year's spell. Perennial Rye Grass had given outstanding results on old ground.

"Rural Universities"—A Symposium.

Dr. R. B. Madgwick, Vice-Chancellor, New England University, Dr. C. Roderick, Education Editor, Angus and Robertson Pty. Ltd., Dr. I. S. Turner, Principal, Sydney Teachers' College, and Dr. H. C. Forster, Executive Officer of the C.S.I.R.O. and President of the Australian Institute of Agricultural Science.

Dr. Madgwick in opening the symposium, stated that, in his view there should not be any differences in attitude to Rural and other Universities. The functions of a University are essentially the same wherever it is located. He considered that the concept of a specialist University was wrong and not in the best interests of a true university education. Development of a University appropriately begins with the establishment of the basic faculties of Arts and Science. Dr. Madgwick was not in agreement with the establishment of a University in a country area primarily to provide tertiary education in agriculture or other rural fields.

Dr. Turner dealt with the subject from the point of view of decentralisation of education in New South Wales. A basic need of education is that it should be decentralised and administered by a local regional education authority with a strong bias towards self-help. For the purposes of decentralisation of industry the state was divided into 17 regions by a Committee set up some years ago. Each has 12-25,000 children of school age, ample for primary and high schools but no one region could extend education beyond the secondary level, nevertheless groups of neighbouring regions could well do so. Excluding the area served by the New England University, three other areas could each support a University. A rural University or University College should cater for regular full-time students in the 17-21 years age group, for student teachers and for adults, both as part-time students and through extension courses. It should be based on arts and science faculties but should also organise other "service" departments which would cater for the needs of non-resident students. It would be a residential institution and much use should be made of organised Summer Schools to bring outside students into residence for a short time. This concept of a university is one widely accepted on the North American continent.

Dr. Forster felt that the establishment of rural universities, as well as extending tertiary education, could greatly relieve the twin major problems in the present capital city universities of large student numbers and shortage of accommodation. He felt that the establishment of rural universities with restricted schools, e.g., Arts and Sciences, was most practicable. Duplication of a complete university was very costly and not in the best interests of specialised university education, while establishing a University or University College around a single faculty (e.g. Agriculture) was impracticable because of the teaching required from allied schools. A country university, if linked with

agriculture or veterinary science, as are the American Land Grant Colleges, would have many advantages. One such rural university in the U.S.A., which could well serve as a model for us, is that at Ames, Iowa. It has now a number of undergraduate schools, with the emphasis on rural sciences but backed by arts and the basic sciences and a very good post-graduate school. There is a close linkage of teaching, research and agricultural extension in the one University centre which plays a vital part in the community.

The Victorian solution to the problem of over-crowding of Melbourne University by transferring certain first year courses to Mildura was a successful one despite the cost. This success is largely due to the much closer relationships between students and between students and staff at Mildura.

Dr. Roderick made a plea for the re-organisation and extension of secondary and tertiary agricultural education. The provision of agricultural education is a *public* concern. Although one-third of the wealth of New South Wales comes from rural industries and improved agriculture is essential for our future social stability, expenditure on agricultural education falls far short of present and future needs. The unbalance of present policy is illustrated by the fact that in 1951 only 144 of the 8,400 undergraduates at the University of Sydney were enrolled in the Faculty of Agriculture and the position has little improved. The keystone of the development necessary seems to be the evolution of a rural university organised around a central School of Agriculture. Such an institution should logically be established in the south-west of New South Wales, where agricultural potentialities are highest and most diversified, at Wagga which is the natural centre of the area.

In time such a South Western University College, initially concentrating on Agriculture, would grow into a University offering a variety of degree courses.

Dr. Roderick criticised the present concept of agricultural education in our high schools and agricultural colleges. He urged the constitution of a council of Agricultural Education with strong executive powers as an important step in the general re-organisation of agricultural education in New South Wales.

"The Development of the Waite Agricultural Research Institute."

Professor J. Prescott, then Director, Waite Institute.

Professor Prescott traced the early history of Peter Waite and his business associates and friends to the foundation of the Waite Institute and then outlined the way some of the activities of the Institute had developed. Of particular interest was his description of the struggle in the early committees between the advocates of an "academic" and "practical" character for the future institute.

Peter Waite emigrated to Australia at the age of 25 (in 1859) and was associated first with his brother James at Pandappa sheep station and then with Thomas Elder at Paratoo and other stations. He was the first Chairman of Directors of the present firm of Elder, Smith & Co. when it formed in 1888. In 1874 he bought Urrbrae Estate from the widow of R. L. McGeorge and made his permanent home there. Interestingly enough, the name "Urrbrae" was coined from the Scottish village of Urr from which the McGeorge family came.

As far back as 1889 Professor E. H. Rennie, Angas Professor of Chemistry in the University of Adelaide, urged the need for research in Agriculture in his Presidential address to the Royal Society of S.A., and at a later date again drew attention to the lack of such research and the obvious need for it.

In 1913 Peter Waite offered immediate title of "Urrbrae," subject to a life tenancy of his wife and himself, to the University of Adelaide for the purpose of University work in Agriculture, Botany, Entomology, Horticulture and Forestry, interpreted in their widest sense.

The University set up a committee in 1915 "to consider and report upon the best means of utilising the gifts of Mr. Peter Waite." This committee included Professor Rennie, the Directors of Agriculture and of Education, and Mr. Walter Young as well as an abundance of others. The chief recommendation from the committee was that an Agricultural Investigation Station be set up and that a Director, who amongst other things must be a competent agriculturist, be appointed.

In 1918 Peter Waite added to his gifts by establishing an endowment fund. Shortly after the death of Peter Waite and of his wife in 1922, the University appointed another committee to report on the Waite bequest. It was decided to establish a "Waite Agricultural Research Institute;" the State Government was successfully approached with a request to extend its grant to include the Waite endowments; and the Institute began in 1924 with an assured annual income of £8,000.

It was clear from the address that throughout this early period and later the sympathy, guidance and practical help of Walter Young, a personal friend of Peter Waite and General Manager of Elder Smith & Co., were of the utmost importance to the Institute.

Professor Prescott then traced developments which took place after the appointment of Dr. A. E. V. Richardson as first Director and Professor of Agriculture, and of himself as Professor of Agricultural Chemistry. Of particular interest to members of the A.I.A.S. was the realization that the Waite Institute has acted as the cradle of new research organisations such as the C.S.I.R.O. Division of Soils and the Wine Research Institute.

"Apricot Fungal 'Gummosis'."

L. C. Smith and M. V. Carter.

In introducing the discussion on "Gummosis" of apricots, Mr. Smith pointed out that the name "Gummosis," by which the disease has been known for more than twenty years, is an unfortunate one because gumming is a symptom associated with at least four other conditions in apricots.

The disease was first described in South Australia by Mr. Samuel in 1932, when it was

recorded that 10% of the apricots in the Barossa Valley were infected. In the intervening twenty-three years the incidence of this disease has increased to 60%. Surveys and experimental work carried out mainly by Miss Grace and Mr. D. B. Adam established that: Apricots and to a lesser extent prunes, are susceptible to the disease; all varieties of apricots are susceptible; the prevalence of the disease cannot be associated with stock, soil, irrigation practices, or manurial treatments, and that infection takes place through wounds. Finally Mr. Smith described a modified pruning technique which has made possible a very substantial degree of control of the disease. The aim is to produce a tree which bears its fruit on extended laterals, so that if infection should occur, the infected portion can be removed entirely with very little loss of tree framework.

Mr. Carter next described the work carried out in recent years to determine the means of dispersal of the disease since the first demonstration of the pathogenicity of a fungus of the genus *Libertella* by Mr. Samuel in 1932. The only known method of sporulation of this fungus was such that it was unlikely to be responsible for the widespread distribution of spores which could initiate infection. An intensive search for a perithecial stage of the pathogen was carried out and early this year an isolate of the genus *Eutypa* from a dead apricot limb was found to be pathogenic. This fungus is now known to be widespread in dead apricot limbs in South Australia, southern Victoria and Tasmania, and it is well adapted for the widespread dissemination of the disease. The ascospores of this fungus are light and small and can easily be carried over great distances by wind currents. They are forcibly ejected from the perithecia after a rain of five points or more, at the rate of approximately nine thousand million per square centimetre of infected dead apricot wood, and there are many tons of such wood scattered throughout southern Australia. The spores are viable for up to six weeks after ejection. Infection of pruning wounds has been shown to be most common during the period from September to December under South Australian conditions. This is probably due to the fact that later than December moisture is a limiting factor in spore germination, and earlier than September the low temperatures make spore germination very slow and infection correspondingly less likely. With the source and the mechanism of dispersal of the pathogen responsible for "Gummosis" of apricots now known, and by the use of the modified pruning technique the control of the disease would at last appear to be possible.

PERSONAL NOTES

Professor Sir Samuel Wadham

Professor Sir Samuel Wadham, Dean of the Faculty of Agriculture at Melbourne University, was created a Knight Bachelor in the New Year's Honours List.

The award was made for long and meritorious service to Agriculture in Australia.

Sir Samuel Wadham has held the Chair of Agriculture at Melbourne since 1926, and during this time has seen over four hundred Agricultural Scientists graduate from the School.

His interests in Agricultural matters have been many and varied. He has served on many committees investigating various aspects of agricultural production, in particular a study of the dairying industry in 1928 and the wheat industry in 1929. Further, he was a member of the Royal Commission into the wheat, bread and flour industries in 1934 and was a member of the Rural Reconstruction Commission in 1943.

Sir Samuel has always had the welfare of the farmer at heart and much of his energy has been directed towards a better understanding of the economics of farming, having in mind the development of a stable agriculture which allows the farmer to work under good conditions and obtain a just reward.

Sir Samuel was Federal President of the Institute in 1937-38 and has always been active in Institute affairs both in the Federal and State spheres. He was the first recipient of the Institute Medal in 1948.

It is pleasing that Sir Samuel's services have been recognised in this manner.

Australian Capital Territory.

Mr. Ron Sherwin recently left Canberra to take up his appointment as Agricultural Attache at the Australian Embassy in Washington.

Dr. R. D. Brock has been awarded a Leader Specialist Grant by the United States Government which will enable him to spend three months in the U.S.A. looking into the use of radiations for the production of mutants of agricultural use. Dr. Brock will leave for U.S.A. in April and return via U.K. and Sweden arriving back in August.

Mr. A. Shavitisky has been appointed Chief Scientific Liaison Officer at the ASLO in London for a period of two years. Mr. Shavitisky is at present making a tour of C.S.I.R.O. and University research establishments prior to his sailing in May for London.

Mr. W. Hartley will leave shortly for a four months visit to the U.K. and Europe. While in Europe, Mr. Hartley will attend the International Conference of the Association of Seed Testers.

Miss N. T. Burbidge has returned from a collecting trip in the southern littoral of Western Australia. Miss Burbidge collected specially *Nicotiana* species.

Mr. C. S. Christian, Officer-in-Charge of the Land Research Section, C.S.I.R.O. and Mr. H. A. Haantjens, leader of the New Guinea survey unit of the Section visited Papua/New Guinea in February to study the present agriculture of the Territory and had discussions with officers of the Administration concerning the survey programme of the Section.

Mr. C. S. Christian in his capacity as Arid Zone Research Liaison Officer, visited the Wiluna-Meekatharra Area of Western Australia last November in company with Dr. R. C. Rossiter of the C.S.I.R.O. Division of Plant In-

dustry and officers of the Western Australian Department of Agriculture.

Queensland.

Mr. W. W. Bryan, Senior Agronomist, Plant and Soils Laboratory, C.S.I.R.O., will spend five months in the following tropical and sub-tropical countries of North America—Mexico, Costa Rica, Jamaica, Cuba, South-eastern U.S.A. and Hawaii. The main objects of this visit are pasture investigations and the collection of pasture species including legumes. Mr. Bryan returns to Queensland during early June.

Mr. A. J. Schindler, Senior Agricultural Officer and Manager of the Highlands Agricultural Experiment Station, Aiyura, and *Dr. H. E. Young,* Director of the Rubber Research Institute, Ceylon, recently spent their recreation leave in Brisbane.

Mr. D. O. Atherton, Director of the Bureau of Tropical Agriculture has transferred his headquarters from South Johnstone to Cairns.

Mr. B. B. Brett, formerly Technical Officer, Plant and Soils Laboratory, C.S.I.R.O., has joined the staff of Houghton and Byrne (Q.) Pty. Ltd.

The dual position of Agricultural Chemist and Biochemist within the Department of Agriculture and Stock, which was held by the late *Dr. M. White* has been abolished. The work of the chemical laboratory has been re-allocated between the Plant Industry and the Animal Industry Divisions.

Mr. C. R. Von Stieglitz, Officer-in-Charge of the Plant Nutrition Laboratory, was appointed Agricultural Chemist in charge of the reconstituted chemical laboratory in the Plant Industry Division.

Mr. L. R. Humphreys, formerly Research Officer in the Department of Agriculture, University of Queensland, was recently appointed Senior Agrostologist, Department of Agriculture and Stock.

Messrs. W. J. S. Sloan, Director of Agriculture, and *F. Chippendale,* Senior Tobacco Agronomist, attended the recent meeting of the Central Tobacco Advisory Committee at Canberra, together with *Mr. C. H. P. Defries,* Assistant Director of Marketing, who is the State representative on that Committee.

Mr. L. M. Rule, formerly Assistant Horticulturist with the Department of Agriculture and Stock, has been appointed Lecturer in Horticulture at Queensland Agricultural High School and College, Lawes.

Two student members for 1955 who recently graduated from the University of Queensland in the Faculty of Agricultural Science have undertaken the following occupations:—

R. W. Downes, Plant Breeder with the Department of Agriculture and Stock; *A. J. Cowan*—raising cattle at Murray Upper via Tully.

Obituary.

Richard Ernest Soutter, retired wheat breeder, died in Brisbane on 12th November, 1955, at the age of 77 years.

Mr. Soutter was born in Hull, Yorkshire, in 1878 and three years later travelled to Australia. He was a foundation student of the Queensland Agricultural High School and College, Lawes. After leaving the College he developed his hobby of wheat breeding.

While still in his twenties he became manager of a State farm at Bungeworgarai near Roma and there he devoted himself to plant breeding without much remuneration or encouragement. In the 29 years that he was manager of the State farm he did much of the wheat breeding that brought millions of pounds to the State of Queensland. Although the breeding of suitable Queensland wheat was Mr. Soutter's signal achievement, he triumphed in breeding a variety of Sudan grass which holds a high place in the estimation of farmers who grow fodder crops.

In 1935, he was transferred to Brisbane to enable him to exercise more general control over the breeding of wheat and to assist in the training of young men to follow him. After reaching the age of 65, the State recognising the great service he had given to the wheat industry, extended his term until 1948, when he retired from the Department of Agriculture and Stock.

In 1951, three years after his retirement from the Department he was awarded the second Honorary Life Membership in the Australian Institute of Agricultural Science. The award was a fitting tribute to a career of splendid service to Australian agriculture.

It is with keen regret that the death of "Dick" Soutter is placed on record, for in his passing the Queensland Branch of the Institute has lost a foundation member who, at all times, enthusiastically supported the aims and objects of the Institute.

South Australia.

Dr. R. J. Best has accepted an invitation to be a Vice-President of Section I at the A.N.Z.A.A.S. Meetings to be held in Dunedin, New Zealand, in January, 1957.

Dr. E. L. Graecen formerly of C.S.I.R.O. Griffith Research Station and more recently farming in New South Wales, has commenced work with the C.S.I.R.O. Division of Soils working on soils physics.

Mr. Peter Byrne has resigned from the position of Dairy Research Officer, Department of Agriculture and has taken up an appointment with the Department of Agriculture in New Guinea. Mr. Max Burton is now acting as Secretary of the South Australian Branch.

Dr. R. L. Specht, Botany Department, University of Adelaide has been awarded Carnegie, Fulbright and Smith-Mundt grants and is studying nutrition of the Chaparral vegetation of California, and the Maquis of Southern France in comparison with the Coonalpyn Downs of South Australia.

Dr. C. G. Stephens visited Brunei, North Borneo during February to make preliminary investigations of the proposed survey by C.S.I.R.O. Division of Soils.

Mr. D. Symon is spending a year's study leave working with Dr. J. W. Gregor at the Scottish Society for Research in Plant Breeding at Edinburgh. He also hopes to spend some time in plant collecting in Greece and adjoining regions in the Mediterranean.

Mr. F. Hilton, formerly of the Agronomy Department, Waite Institute has commenced as a Senior Master, Education Department, and is stationed at Glossop.

New South Wales.

Associate-Professor J. M. Vincent, Associate-Professor of Microbiology at the University of Sydney's School of Agriculture has been granted the degree of D.Sc. (Agr.) by the University for a thesis entitled "Root-nodule bacteria of Pasture Legumes." Prof. Vincent has been working in this field for a number of years and his work has gained him international recognition.

Professor J. A. McMillan, Dean of the Faculty of Agriculture at the University of Sydney, visited Pakistan in January as delegate from A.N.Z.A.A.S. to the meeting of the Pakistan Association for the Advancement of Science. On his way back Prof. McMillan visited agricultural institutions in India, Ceylon, Malaya and Singapore.

Tasmania.

Mr. L. W. Millar, Chief Entomologist, returned from a visit to U.S.A., Canada and England to study the latest developments in the field of entomology.

Mr. F. Walker, Chief Horticultural Officer of the Department of Agriculture, returned home after a visit to South Africa, England and the Continent. He assisted Commonwealth Officers in fruit inspection and while on the Continent represented Australia at the International Horticultural Congress.

A symposium on Trace Elements was held at the University of Tasmania on 22nd September, 1955. Those who spoke were Dr. P. R. Stout, Messrs. K. D. Nicholls, D. F. Paton, R. J. Green, G. C. Wade and D. Berry.

Victoria.

Mr. R. D. Croll has been appointed Victorian and Tasmanian Sales Manager for New Holland Australasia Ltd.

Miss I. J. Stewart left for Canada early in the year, where she is to work at the Central Poultry Station at Ottawa.

Western Australia.

Mr. I. Thomas retired in December, 1955, after 42 years of distinguished service with the Western Australian Department of Agriculture. Mr. Thomas' first position was manager of the Chapman Research Station. In 1924 he was appointed Superintendent of Wheat Farms and some years after became Superintendent of Wheat Farming. In 1953 he was appointed Deputy Director of Agriculture, which position he held on his retirement.

Dr. T. C. Dunne has been appointed Deputy Director of Agriculture. As Chief Plant Research Officer, Dr. Dunne has been responsible for the direction of research in pastures, cereals, vegetables, vines, flax and orchard crops.

Some results arising from these investigations include the use of copper to overcome die-back in apples, the use of molybdenum for cauliflowers and pastures, and the use of zinc for cereals and pastures.

Mr. A. M. Stewart, Assistant Director of the Institute of Agriculture and Reader in Agriculture, left for Europe on the 27th January. He is taking sabbatical leave and will visit places of agricultural interest in Europe and the U.K.

Mr. N. A. Bluman, a post graduate student at the Institute of Agriculture, has been awarded a C.S.I.R.O. Studentship tenable for two years. He will continue his work on animal nutrition at the Institute.

Mr. D. P. Fischer has returned to W.A. after 2 years abroad and has taken up an appointment as an Agricultural Adviser with the Rural and Industries Bank.

Mr. B. Edwards has resigned from the Dept. of Agriculture to take up an appointment with the I.C.I.A.N.Z.

Mr. J. E. Eckersley has been appointed assistant Superintendent of Horticulture.

BRANCH NOTES

Australian Capital Territory.

The 121st General Meeting was held at University House on 14th November, 1955. The President was in the chair and 27 members and visitors were present.

Mr. G. A. Helson, Research Superintendent and Officer-in-Charge of Plant Quarantine in the New Zealand Department of Agriculture addressed the meeting, his subject being "Present Day Plant Quarantine in New Zealand".

New South Wales.

There was an attendance of 45 members and visitors at the ordinary general meeting of the Branch held in Sydney on 31st October, 1955. The main business was a symposium on "Rural Universities" which formed an important part of the current enquiry by the Branch into the training of agricultural scientists. The principal speakers were Dr. R. B. Madgwick, Vice-Chancellor, New England University, Dr. Colin Roderick, Education Editor, Angus and Robertson Pty. Ltd., Dr. I. S. Turner, Principal, Sydney Teachers' College and Dr. H. C. Forster, President of the A.I.A.S. and Executive Officer, C.S.I.R.O.

Queensland.

The Branch held its postponed country meeting at the Maroochy Experiment Station, Nambour, on October 22nd. The meeting was convened on the basis of a family day for members, their families and friends. At Nambour, *Mr. P. Mitchell,* Manager of the Station, briefly outlined the history of the Station and its importance in the horticultural production of the area near Nambour and its influence on horticulture throughout the State. *Mr. R. C. Cannon,* Senior Horticulturist, gave a summary of the experimental activities, and *Messrs. G. W. J. Agnew,* Senior Experimentalist, and *F. W. Berrill,* Horticulturist,

supplemented this summary with a short tour of inspection of the plantation crops.

The final Branch meeting for 1955 was held on November 23rd. This meeting was devoted to the *Queensland Branch Prize* which is offered annually to the undergraduate of the Faculty of Agriculture, University of Queensland, who presents the best paper to an examining sub-committee. The benefits of the meeting to both students and the Institute have become more and more widely appreciated in Queensland. The three student finalists for 1955 were *Messrs. J. K. Leslie, R. W. Downes* and *A. J. Cowan.* The Branch adjudicators—*Messrs. C. G. Hughes, S. A. Waring* and *Dr. D. O. Norris*—awarded the prize to Mr. J. K. Leslie for his paper entitled "The effectiveness of three cultural methods in seeding spear grass pastures."

The Executive Officer, *Mr. J. A. Roberts,* was in attendance. The President requested him to inform members on current activities of the central secretariat. Mr. Roberts outlined the "plan ahead" which is dependent on financial support to the order of £10,000, for the next five years, from members of organisations with rural and allied interests. He suggested that the money should be utilised by furthering recruitment into the profession and secondly by a campaign for increased circulation of the Institute Journal.

South Australia.

On 14th October, a symposium on "Development on Kangaroo Island" was given by three speakers; Mr. Rowland Hill of the Land Development Executive, Department of Lands, Dr. C. S. Piper, Reader in Agricultural Chemistry, University of Adelaide and Mr. E. D. Carter, Parndana Research Centre, Department of Agriculture.

At a meeting on 11th November, Professor J. A. Prescott gave an interesting address on "The Waite Institute: Retrospect and Prospect."

On 9th December, Mr. L. C. Smith of the Horticulture Branch, Department of Agriculture and Mr. M. V. Carter of the Plant Pathology Department, Waite Institute, spoke on "Apricot Gummosis."

Victoria.

The Annual Garden Party to welcome new graduates was held at the Agriculture School, University, on 9th December. Once again the function was a great success and gave members the opportunity to meet those who have now joined graduate ranks.

The Australian Plant Nutrition Conference, 1956, was held at the School of Agriculture, Melbourne University from February 27 until March 2. This conference was attended by representatives of organisations which are concerned with aspects of plant nutrition and in order to provide an informal gathering where all could meet together, the members of the Victorian Branch of the Institute acted as hosts at a Garden Party held in the grounds of the Agriculture School on Wednesday, 29th February.

Symposium.

A symposium entitled "The Recruitment and Training of Agricultural Scientists" was held at the School of Horticulture, Burnley Gardens on 23rd March. This subject was suggested as a result of the 1955 Symposium where it was quite evident that members regarded recruitment and training methods to be of major importance.

The programme was drawn up in such a way as to cover all aspects of the problem. Two papers were presented by Schools' Inspectors of the Education Department and headmasters of schools concerned with Agricultural subjects were present at the sessions dealing with pre-University training.

In broad outline the programme was as follows—

Session 1.—Recruitment.
- (a) Scholarships and Bursaries.
- (b) Public relations in relation to teachers, parents and students.

Session 2.—Pre-University Training.

Session 3.—University Undergraduate Training.
- (a) The basic course including minor special subjects, e.g., statistics.
- (b) Specialisation in major fields in the B.Agr.Sc. course.

Session 4.—Post-Graduate University Training.

Review Session.

Survey.

The Salaries and Status Sub-Committee of the Victorian Branch is at present conducting a survey of working conditions of members.

Annual General Meeting.

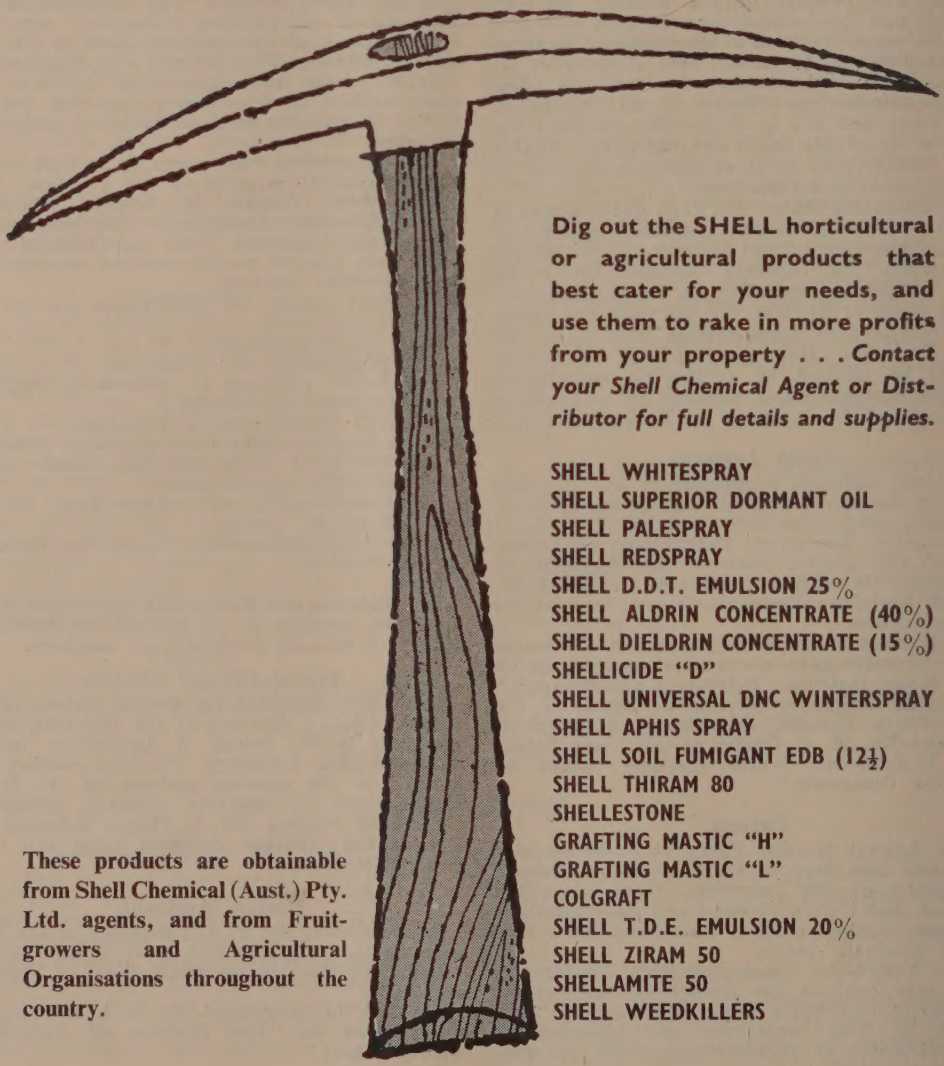
The party preceded the second session of the Annual General Meeting of the Institute, which was held in the School of Agriculture on the 28th and 29th February. The first evening was devoted to the opening address by Dr. H. C. Forster and to Institute business, whilst on the second evening Dr. I. Phipps delivered the Presidential Address deferred from the 22nd General Meeting.

Western Australia.

In December, Mr. B. J. Fennessey of the Wild Life Section of C.S.I.R.O. gave a talk on the "Rabbit Problem in the South-West of Western Australia."

On 20th January, 1956, Dr. G. L. Sutton gave an address on "The Problem of Australian Strong Wheat."

Take your pick . . .



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DIVISION OF PLANT INDUSTRY

PLANT AND SOILS LABORATORY—BRISBANE

The major objective of the Laboratory is the development of improved pastures for both beef and dairy cattle in sub-tropical Queensland. Low productivity and low nutritive value of the pastures is a reflex of erratic rainfall distribution, low soil fertility, and relatively unadapted species of pasture plants. Especial attention is given to extending the range of variability in plants by introduction and plant breeding, and to increasing soil fertility both by the use of legumes and the correction of nutrient deficiencies. Research is also being carried out, under the general direction of Dr. J. Griffiths Davies, in the fields of animal nutrition, ecology, agronomy, legume bacteriology and biochemistry. The laboratory has a total of twenty research officers, including a research group from the Division of Soils.

It is proposed to make three new research appointments.

1. **Plant Geneticist (Appointment Number 146/75).**

The appointee is to take part in breeding and genetical studies designed to develop legumes and grasses suitable for the sub-tropical belt of Queensland. Problems include studies of breeding systems, of the nature and scope of variation in intra and interspecific crosses, of induced mutations, of the genetic, morphogenetic, and physiological bases of apomixis and the occurrence and possible induction of sexuality in certain grass species.

The appointee will have access to and contact with the large team of geneticists at the Division's Canberra laboratory, to which Dr. M. J. D. White and Dr. O. H. Frankel, F.R.S., belong.

2. **Plant Nutrition Officer (Appointment Number 146/73).**

The appointee will take part in plant nutrition research with special reference to studies of the effects of applying nitrogen to sub-tropical pastures. Direct yield effects, and changes in both botanical composition, and nitrogen cycle equilibrium in pastures under the influence of added nitrogen require study in this environment.

3. **Pasture Ecologist (Appointment Number 146/74).**

The appointee will take part in research into the ecology of sub-tropical pasture mixtures and associations. His work will involve, primarily, research into pasture mixtures for use in the climatic and exaphic environments of Queensland, with special attention to the inclusion of legumes. Research into competition and compatability between species in pasture mixture will be an important part of the work.

QUALIFICATIONS:

University honours degree in science or agricultural science, preferably with relevant post graduate research experience.

SALARY:

Dependent on qualifications and experience; commencing salary for all three positions will be determined within the range of Research Officer, £1,263 to £1,888 p.a.

Applications, referring to the appropriate appointment number, should reach the Associate Chief, Plant & Soils Laboratory, C.S.I.R.O., Parliament House Post Office, George Street, Brisbane, Queensland, not later than 31st March, 1956.

DU PONT

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